"FOREST MANAGEMENT - MADE EASY"

By

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CONTENTS

			Page
PREFACE		.. ..	
CHAPTER	I	INTRODUCTION	1
	II	OBJECTS OF MANAGEMENT	7
	III	SUSTAINED YIELD	14
	IV	ROTATION	21
	V	NORMAL FOREST	31
	VI	ACTUAL GROWING STOCK AND ITS INCREMENT	34
	VII	YIELD REGULATION	53
	VIII	YIELD REGULATION APPLIED TO INDIAN FORESTS ..	75
	IX	MULTIPLE USES OF FORESTRY	77
APPENDICES			
	I	SOME ECONOMIC TERMS EXPLAINED ..	83
	II	"ECONOMIC ANALYSIS OF FOREST HARVESTING " BY SHRI R.L.CHOUDHURY,IFS	86
	III	MODEL QUESTION PAPERS	90
REFERENCE		.. ..	95

PREFACE

FOREST MANAGEMENT is aptly called APPLIED FORESTRY. It embraces many forestry basic subjects such as Silviculture, Silviculture of Species, Silvicultural Systems, Mensuration, Protection, Forest Policy, Forest Planning and Forest Economics, etc. and therefore the study of Forest Management is a MUST for every potential Forest Officer.

The present little book is prepared for the benefit of Forest trainees strictly following the syllabus prescribed. Since the books available on Forest Management do not contain all the topics included in the syllabus, the students have to scan through within the shortest possible time many books. Though they are advised and encouraged to read as much literature as possible to get deeper appreciation of the subject, this is prepared mainly for their quick grasping of the subject and as a compact handy tool based fully on the syllabus.

This is my third book after Forest Policy and Forest Protection prepared for Forest Trainees which is the result of constant encouragement showered on me by Shri P. Baskaradoss, I.F.S., Principal, State Forest Service College, Coimbatore, to whom I am greatly indebted. I am also grateful to Shri M.L. Ramprakash, I.F.S., Principal, Southern Forest Rangers College, Coimbatore, for his kind perusal of the script and expert appreciations and comments.

Critical suggestions for further improvement on this book are cordially welcome with gratitude.

Thank you.

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CHAPTER - I

INTRODUCTION

MANAGEMENT is an art as well as Science. As an art it requires skill, talent and intelligence, on the part of the manager, As a science it is amenable for experimentations, innovations, Research, application of various methods, arriving at a scientific conclusions and adoption of such conclusions in identical spheres and situations.

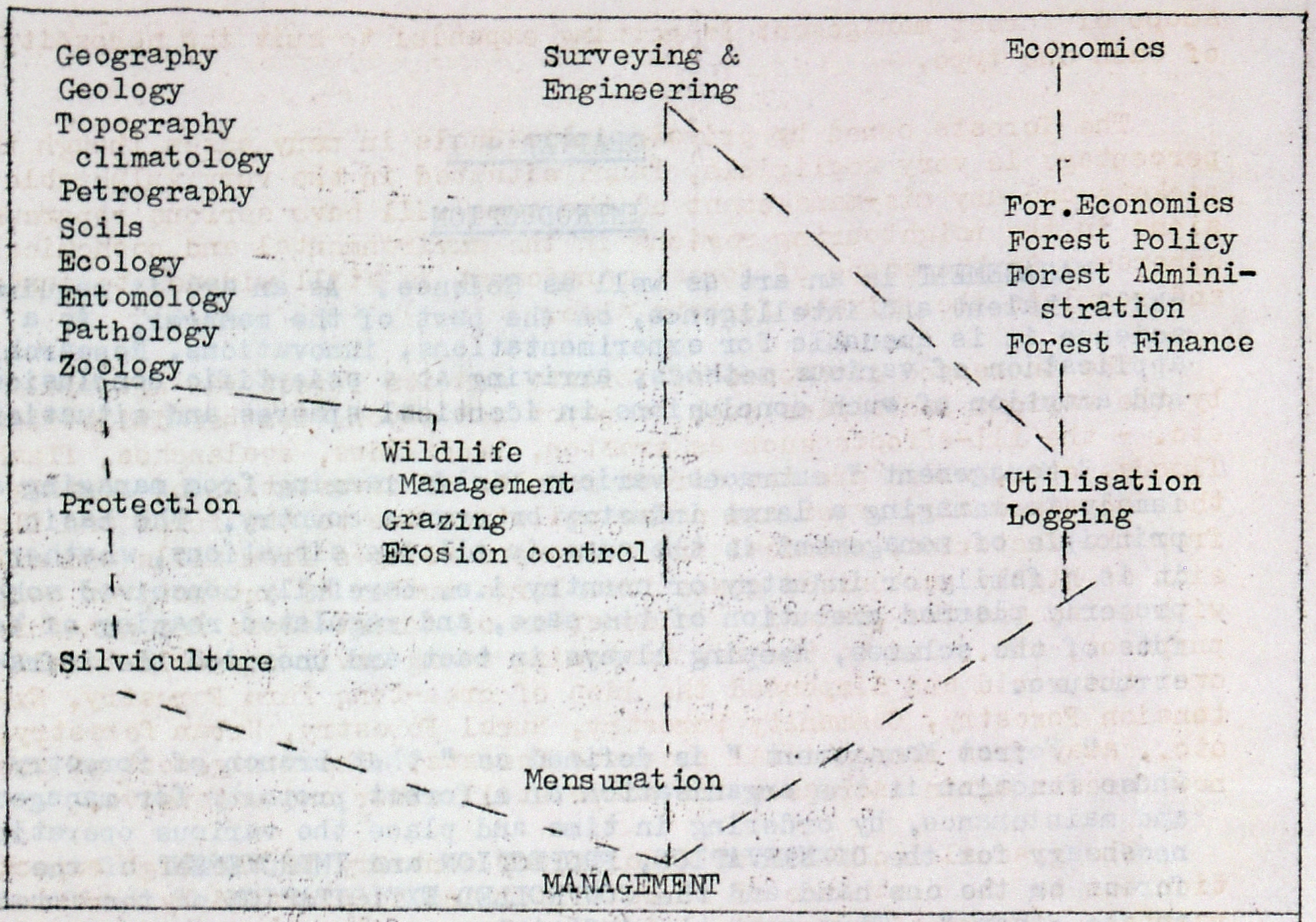
" Management " embraces various fields ranging from managing a family to managing a large industry or even a country. The basic principle of management is the same in all the situations, whether it is a family or industry or country i.e. carefully conceived schemes, properly planned execution of the same, and regulated reaping of benefits of the schemes, keeping always in tact and uneroded the infrastructure.

" Forest Management " is defined as " that branch of forestry whose function is the organisation of a forest property for management and maintenance, by ordering in time and place the various operations necessary for the CONSERVATION, PROTECTION and IMPROVEMENT of the forest on the one hand and the CONTROLLED EXPLOITATION of the forest on the other ". Thus runs the definition as per Glossary of Forestry terms published by FRI.

According to defintiion of Society of American Foresters (1958), Forest Management is the application of BUSINESS METHODS and principles of TECHNICAL FORESTRY to the operation of a forest PROPERTY".

While Indian point of view embraces all the functions of forests, Americans have taken only the "productive " function of the forests as the basis of management. More-over, there, the major portion of forests is under the control of private individuals, their policy guides both the private and public forest owners whose main aim is the maximum amount of profit. Here in India, the position is entirely different in that the major portion of the forests is under the Government control and the Government has got the dual responsibilities of economic and sociologic welfares.

<u>SCOPE:</u> Broadly speaking, the Forest Management involves the application of knowledge gathered in the whole field of forestry so it can be called " <u>Applied Forestry</u> ". The following diagrammatic expression will explain that the Forest management is truly the " Applied Forestry ".



Based on " Forest Management " - Meyer-et-al

In its restricted sense, it is more especially concerned with the organi ation of a forest for the purpose of securing a sustained yield from it and for realising the objects of management of the owner.

The ownership of forests may be resting on private as well public (Government). In countries like U.S.A., large chunks of forests are under private ownership while in the socialist countries like U.S.S.R., China, the forests belong mainly to the people (public) and only a negligent portion with private ownership. Thanks to the Britishers, large areas of forests in the form of Reserved forests, were inherited and after Independence by abolition of princely states and Zamindaris, some more forested lands were added to the Government control. Only a negligent per cent (1.6%) is under the private control. The Government forest, if left alone, could have been flourished to the benefit of the whole public. But the interference of various vested interests which made many inroads into the forests in the last few decades, brought down considerably the area under forests. Within 35 years of our independence we have lost about 4.5 million hectares of forest area for non-forestry purposes. The irony of fate is that when the area under forests is decreasing, the dependence on forests and forest raw materials and products is mounting. Hence the scope of forest management especially in India is very wide and intense.

The different and varied climatic conditions prevailing in our country which is a sub-continent in reality, have given rise to varied types of forests (16 major types are identified vide the Government of India Publication - Development of Forestry and Forestry products - 1981) which have to be managed specifically than generally. Once again

scope of forest management is getting expanded to suit the necessity of each one type.

The forests owned by private individuals in many cases though the percentage is very negligible, found situated in the very vulnerable pockets and any mis-management of the same will have serious repercussions in the neighbouring regions in the environmental and economical spheres. So the scope of forest management is still widened to control and regulate the private forests also.

The increased dependence of forests and its forest raw materials by the various industries such as paper and rayon, leather industries, etc. - the ill-effects such as erosion, landslides, avalanches, flash floods, etc., which are the direct results of devastation of forests - the increased air, water and noise pollution due to the fumes and flames from the factories, chemical and poisonous refuges from mills and emission of highly carbonised gases from large number of automotives coupled with noise and the gradual alienation of forest areas for non-forestry purposes, etc., led to the new awakening among environmentalists all over the world and dispensed the idea of crea-ting Farm Forestry, Extension Forestry, Community Forestry, Rural Forestry, Urban forestry, etc., away from conventional reserved forests. The management of such new forests again increases the scope still wider and extensive.

The gradual depletion of Hydel power contrary to the high expectation due to the clearance of forest floor and accelerated by erratic rainfall, the rapid exhaustion of thermal power (coal) and petroleum production which are non-renewable ones are casting a dangerous shadow on the mankind in the form of Energy crisis. Apart from the frantic efforts to harness the solar energy as alternate source of energy, the idea of creation of " energy " plantations of suitable wood species which are the natural store-houses of solar energy is catching the attention of the energy hungry world. Such energy plantations have to be managed in a different way than the ordinary fuelwood plantations. Here again the scope of management gets widened still further.

From the above small discussion, it may be quite clear that within the short span of three decades, the responsibility of Forest Manager has increased manifold and varied drawing his full attention and draining all his skill.

MANAGEMENT OF FOREST AND THEIR PECULIARITIES:

It is the age old concept that the forests are managed for the twin purposes, viz., (a) Protective and (b) Productive. The former is for the physical benefits which they confer such as supply of perennial water to the streams and rivers, amelioration of climatic conditions, provision of aesthetic beauty and shelter to the wildlife, etc. And also as the great barrier against soil erosion in the slopes. They consist mainly of the high altitude natural forests, forests capping the preciptuous slopes, forest farming the water-shed areas, stream, canal and river banks, coastal belts, etc. These forests if naturally occurring, they have to be protected invariably and the management here aims only at the conservation of them. Such areas, if depleted or devoid of forest cover/they have to be planted up and brought under forest cover as quickly as possible. It is noteworthy to re-collect the recommendation made in the 1952 National Forest Policy which required " an immediate and speedy programme for the reconditioning of the mountainous region, river valleys and coastal lands by establishing

protective cover over larger areas and by preserving the existing ones ". And also it emphasised that " the scientific management of such protection forests wherever possible, should include the production and exploitation of timber within the limits of safety ". So, even those protected areas may have sometimes, some commercial utility. And in that case, their management is to include such limited, safer exploitation of timber. For example, better plywood inner layers can be obtained only from the shola species that grow in evergreen sholas only. Strictly speaking, evergreen sholas are to be protected very carefully.

The second category of forests are productive forests which are to be managed mainly under business or commercial basis. Actually our study of forest management revolves round these types of forests only. Anyway as said earlier our study of management touches some pockets of protection forests also. It shall be borne in mind that even in the management of productive forests, the important physical requirements shall have to be served otherwise, we will be killing the " goose that lays golden eggs ", and the sustained enjoyment of that forests by future generations will be blocked.

Apart from these two age old concepts, now we have one more purpose known as " Sociological purpose ". 1976 Report of NCA in one of its recommendations (para 41.5.16 and 41.5.17 and 41.5.20 of Part IV wished to classify " the Indian Forests functionally into (a) Protective forests (b) Productive forests and (c) Social forests. Accordingly the social forests " would cover waste lands, panchayat lands, village commons and lands on the side of roads, canal banks and Railway lines, which may be brought under forest plantations, shelter belts and mixed forestry, comprising raising of grass and leaf fodder, fruit trees and fuel wood trees ". It even wanted " to create wood lots with irrigation on suitable lands in the command areas of irrigation projects that may come of later " and " such wood lots should be classified under " Social Forests ". So, now we have entered into an era of " Three dimensional forestry " and so management of such social forestry also have to be included in our study.

PECULIARITIES OF FORESTS:

D.R.Johnston said that " Forests are valued for the GOODS and SERVICES they produce". So the forestry is considered similar to any other industry and project evaluation and estimation as in the case of industries are also attempted in Forestry also. Now-a-days large amount of money is being invested in forestry and economy requires proper money return from such investment. But certain peculiarities are present or inherent in forests and forest management.

The productive forests which is the subject matter of our study, is not of uniform character and composition. Besides, we have "naturally regenerated " forests as well as "man-made forests ". Again the natural forests have many species and all the species are not harvestable. Added to that, different species have different rate of growth reaching different periods of harvest. Whereas in case of man-made forests also, different species are raised with different periods of harvest. Even the same species may have different periods of harvest, in different localities based on the local distinct climatic and soil conditions. All these factors pose peculiar problems for forest manager.

Though the forestry is compared to industry or agriculture, there

are distinct differences which make out forestry a complex and peculiar form of industry. They are listed below:

Forestry	Industry or Agriculture
1. It is a long term investment since the gestation period is pretty long.	1. Comparatively short term investment. Once the Capital is invested, the production can be started within a year or two. In agriculture harvesting is obtained in a year or several times in a year itself.
2. Once money is invested, here capital and the product are one and the same and cannot be distinguished which requires pre-planning a series of plantations having continuous age gradations and mature crop only harvested.	2. Capital may be in the form of machinery, etc., and the product is distinguishable from the capital.
3. Slow growth of timber shows a moderate rate of return (Rate of growth in India is 0.43^3 only when compared to the world average of $2.5m^3$).	3. Better economic return is always possible as the productive period can be shortened.
4. Vagaries of nature plays an important role in forestry operations and future yield depends mainly on favourable natural conditions or factors i.e. Locality factors.	4. Vagaries of nature does some effect in agriculture but in industry, they can be safe-guarded against natural factors and assured production can be expected.
5. Detrimental effect of unfavourable locality factors at any one time will have telling effect very late nullifying the principle of sustained yield.	5. Production can be ensured by mechanical manipulation and natural factors will not have much devastating effect in the future expectation.
6. There is the real danger of the capital being eroded due to ignorance or inadvertance or by overfelling in view of the temptation of higher prices for the produce.	6. No such danger of capital is being encroached upon.
7. In case of natural forests, normalcy is a casualty. The ill-distribution of age classes will make matters complicated.	7. No such contingency may arise.

PRINCIPLES OF FOREST MANAGEMENT AND THEIR APPLICABILITY

The most celebrated principle of forest management all over the world is the " Principle of Sustained yield ". The definition and detailed discussion of this principle will be done under a separate Chapter titled " Sustained Yield ". This principle can be applied only to the forests which are to be permanently retained as such. For smaller forest blocks and the lands cleared for forest growth for the extension of cultivation or for industrial or engineering purposes, this principle will not be of any use.

Recently this principle is being criticised as static one and the present day increasing needs cannot be properly satisfied by following this principle. So, a new " principle of increasing yield " was included within the definition of "Sustained yield principle". But this new concept may cover only the forests which are in the early stages of their development.

1939 Dehra Dun Silviculturists Conference and 1948 Helsinki World Forestry Congress saw the emergence of yet another concept known as " Principle of Progressive Yield " since many forest economists complained of the INADEQUACY of the principle of sustained yield, in the present changed circumstances. The protagonists of this new concept argued that Principle of sustained yield is an anachronism in forestry and sterile and static in character. When there is alround progress and scientific advancement in forestry practices such as clonal isolations, tissue culture, hybridisation, introduction of fast growing exotics, etc, they advocated for a DYNAMIC principle which can cope up with the increased demand for forests and forestry products for various purposes. Along with the scientific advancement, the communication facilities such as road formation even into the interior " hitherto-inaccessible " forest areas, introduction fast moving automotives, etc. in hauling, transporting the forest produce quickly to the "hitherto far-off" markets, etc. increased the utility of forest products irrespective of their distant location from the markets. They equated the forestry with that of factories and industries. Though there is some force in their arguments, the natural factors under which forestry has to survive solely, that too for a considerable long period and the risks involved such as pests and diseases, failure of monsoon and periodic fires, thefts and smugglings, during that long period, cannot be overcome easily. The principle of progressive yield may be worth trying only for short timed, fast growing species and to those species which respond readily to the scientific methods but most of the Indian species do not come under such category. So the new concept could not cut much ice in Indian Forestry management and in other countries also, so to say. But the spirit behind this concept is understandable and wherever possible can be tried only for receptive species.

As Mr. Scott put it, " an intellectually satisfactory theory of forest management which can weigh better and more rational against the sustained yield theory is yet to be developed and for such theory, the basis shall be the USER CONCEPT than PRODUCER CONCEPT". We shall strive for such theory!

CHAPTER - II

OBJECTS OF MANAGEMENT

" The primary object of good management is the provision of the maximum benefit to the greatest number of people for all time."

.. BRASNETT, N.V. 1953

1. Purpose and Policy:

In the introductory chapter itself, the different functions of forests were briefly discussed. The generally accepted functional classifications are (a) Protective functions (b) Productive functions and (c) Accessory functions (Recreation, Nature reserves, etc.). In the last, two decades two more classifications have come into picture viz., (1) Economical functions and (2) Sociological functions.

1.1.1 Though the economical functions can come with the Productive functions the present trend is that the former is considered as a separate one so that due regard can be attributed to the Forestry Sector in the National Economical Policy. There was a time when forestry sector was not at all recognised by the economists. (The outlay was in first two Five Year Plans will vouch safe for times) but now the stage has come that no more isolation of forestry sector in the National Economical outlook is possible (vide NCA Report 1976). The most important factor which brought forestry sector into lime light as a most significant one, is its latest "industry oriented " activities or we can say that the newly "bursting out " dependence on forest raw materials by many an industry. According to NCA, the total Industrial wood requirement in 1985 will be around 50 million m^3. The following observations made by the Task Force appointed by Tamilnadu Government in 1970s under the Chairmanship of Dr. Malcolm Adiseshaiah, will hold good not only to Tamilnadu but also to the whole country. " A general conclusion of this evaluation is that planning for afforestation, spread over a period of years, should be essentially industry oriented, in time with the industrialisation programme of the country and the state. This involves a serious re-thinking both in respect of the forest area to be developed and the financial allocation to be made so that more and more forest produce, which can be utilised for industrial growth may be developed instead of allowing nature to determine the kind of produce growing in the different areas " (vide " Paper on Forestry and Industries" by S.Balakathiresan in 1973, All India Seminar at Ooty). The same sentiments were echoed in the NCA (1976) when it analysed the potentialities of forestry as "Productive" means, vide para 12.3.4 under Chapter "Production and Social Forestry" in Part IV of its report which reads as follows:

" We have emphasised that production forestry is a business and it must therefore be closely linked with marketing and utilisation. A forest production programme in isolation will not succeed. The requirement of specific industries should be a major reason for initiating forestry activities, which means a close link between the two. An adequate capacity in the forest based industries should be planned in such a way that the utilisation of the produce from man-made forestry programmes is synchronised with a specific industry which is to go on stream in future. From the economic stand point also there is a strong

justification for bringing about a close link between the resource development and utilisation. The profitability of any plantation project when it is considered in isolation is quite different from when it is linked with utilisation. This is so because in this latter case, the profitability is an integrated one".

1.1.2 The " Sociological functions " of forestry is relatively a new concept. Even though the conventional protective, productive and Accessory functions are only for the ultimate benefit of society only, the new concept envisages the fulfilment of society's aspirations and Society's actual participation and involvement, in Forestry or in the ordinary language in " Tree farming " or " Creation of Green Cover ".

1.1.3 So, any object or objects of management shall first identify the purpose for which Forestry is to be managed and then prescribe a "set of guidelines" for actual management of forest for each identified purpose in the name of " Policies ". So the purpose and policy are the target or goal and the actual ways and means to achieve that target or goal respectively. Management of anything will be successful only when the purpose and policy are pre-determined in clear, unequivocal terms. In case of forestry, pre-determination of purpose and policy is more important and in fact, it is the life line, because, as already explained which is well known fact that Forestry is a long time adventure! and no one or two persons will be in charge of particular forest from the time of creation to the time of harvest and management shall not be left in the mercy of quickly changing personnel.

1.1.4 Normally identified purposes under which the country's or state's forests are to be managed anywhere in the world, are Protective, Productive, Accessory, Economical and Sociological purposes. So each purpose will have a separate guidelines in the name of " Policy ". Several countries have formulated separate policy for each purpose and some have carved out such guidelines for all the purposes in a single document e.g. Indian National Forest Policy of 1952. It was argued by Indian Forest Policy ma-kers that it is very difficult to draw a distinct line for each purposes and earmark particular areas for separate purpose and particular region may serve more than one purpose and it is upto the local forest planners to chalk out management programme. So, a common National Forest Policy can give broad frame work and the inner details can be filled by local Forest managers. Actually latter work is done by this Working Plan Officers concerned. Thus a kind of decentralisation of policy making is allowed to be practised in Forest Management by Divisional Level within the frame-work of National Policy.

1.2 Choice of objectives:

1-2-1 This is the important stage in forest management and any slackness or any defect in this stage will spell a great doom to the forest block concerned and also to the local economy itself. The choice of objectives as far as India is concerned, is mostly left to the states since the Britisher's time, " Forestry" was under the " Provincial lists" and after independence under " State list" till the historic 42nd Amendment to the Indian Constitution, which brought the subject under "Concurrent list ". So, according to the local conditions prevalent, and local demands prevailing, the objectives were chosen. At the time of preparing or revising the working plans, deletion or addition or alteration of objectives were done, as per the directions of respective State Government. One interesting but intriguing example from a State can be

quoted here which will be appropriate to know how the States have changed their stand often which resulted in colossal wastage of time, energy, finance, the utility of that plantations and economy at the later stage. When there was a great demand for matchwood raw materials, the State Government ordered that wher-ever possible matchwood plantations had to be raised. Accordingly, provisions were made in Working Plans. But before the plantations came for maturity either the species did not fare well or the demand for that species died down and the plantations raised could not be sold profitably. Immediately on the score, the Government then withdrew the order of further raising of softwood species.

1.2.2 Indian Forest Management is mainly carried throughout by means of pre-planned "Working Plans ". Though the " Unit of administration " in Forest Department is the " RANGE ", the division comprising of 4 or 5 Ranges is the unit of " Planning programme ". " Working Plan " is the main and only instrument of forest management. It is aptly defined as " a written scheme of management aiming at a continuity of policy, controlling the treatment of a Forest." The detailed study of " Working Plan " is dealt with separately. Anyhow, for our present purpose of understanding, mention is made here. Generally, a Working Plan consists of two main parts. Part I dealing with the locality factors of the division and past systems of management and its results. Part II deals with the " Basis of proposals" and set prescriptions for future management of the Divisional Forests.

1.2.3 As we already know that our Forests are mostly different from region to region, the management cannot be uniform one. Again, the productive capacity of different regions varies considerably. The local demand for particular commodities from forest may also differ from region to region. For e.g. if one region is predominantly agriculture based, the demands may be for grazing, fodder, water supply and agricultural implements, etc. For the region where coal mines are located, the local demand may be for the adequate supply of mine props. So, the management objectives have to commensurate to the local needs mainly.

1.2.4 The another peculiarity of Indian Forests is that the forests extent in India is ill-distributed. Some states like Kerala, Assam, Himachal Pradesh, North Eastern states are having richer forests whereas Haryana, Gujarat, etc. have no forests or poorly endowed with forests. In such cases, excessive forest products available in Forest rich states have to be translocated or marketed in forest poor states. In this case, the management objectives shall take consideration of the demand of other regions also.

1.2.5 Yet another feature to be borne in mind in this context is the proper " Land use Policy " i.e., the potential capability of the each type of forest soil available has to be analysed and the same is put under right species. Knuchel stated that " the objects of management under any circumstances is the most advantageous utilisation possible of the soil allotted to Forestry". So for e.g., the area well suited for production of Teak as pole or timber crop shall not be brought under " Eucalyptus tereticornis " or " Acacia planifrons " cause the latter species are capable of coming up in still drier types of area.

1.2.6 Hence, objects of management have to be properly identified for each local region (Forest Division) within the broad frame work of national Forest Policy (i.e., five functions of forests namely

protective, productive, accessory, industrial and sociological), and according to the local exigencies and the details for each object of management in the form of Working Circle, are worked out and prescribed. For easy understanding an example from a Working Plan, is given here.

Madurai North Division for 1958-68.

" The objects of management are various and may be stated in general as follows:-

(1) To protect, conserve and improve the forest on the hill slopes and plateau in the interest of agriculture, the preservation of excessive erosion and the maintenance of an even flow in rivers and streams and the preservation of high water table.

(2) To exploit with due regard to silvicultural principles the resources of these forests in fuel, bamboo, minor forest produce, etc., with a view to meet the demand of the population to the extent possible.

(3) To work the Bluegum and Wattle plantations at Kodaikanal for the supply of fire wood and poles on a sustained basis and in order to meet the demands for the tamarind bark and incidentally to supply wood fuel to the local and the neighbourring people, till such time as a chip board factory is created in Madurai to consume the wattle.

(4) To grow wattle on a large scale over all the available areas in Upper Palni in order to meet the demands for its tannin bark and incidentally to supply its wood as fuel to the local and the neighbouring people till such time a chip board factory is established to consume wattle.

(5) To grow soft wood species on a modest scale on suitable areas to meet a certain extent the demand from the local match factories.

(6) To provide grazing facilities for the village adjoining the forest consistent with the principles of conservancy.

(7) To enhance the value of the forest for enforcing rigid protection and rehabilitation of the degraded forests.

(8) To protect the forests against damage by fire and men.

(9) To raise Teak plantations on a modest scale in suitable localities with a view to meet the requirement of teak poles to a certain extent.

(10) To preserve the aesthetic value of pine in Kodaikanal by raising pine plantation around the 12 miles round road.

(11) To maintain the forest in a state of increasing productivity.

(12) To take all steps to attain the maximum financial return per acre of forests in perpetuity.

Para 406: With the above objects of managements, it becomes possible to

i) Exploit the available resources of the forests.

ii) Discharge the obligations of the state to the local population.

iii) Conserve, protect and improve the forests.

1.2.6 One more recent example from Working Plan of Haldwani Forest Division of Uttar Pradesh for 1976-77 to 1985-86 is also given for comparison and understanding. The general objects of management are

i) To maintain and improve the forest cover over the hills in the interest of soil and moisture conservation, regulation of streams flow and checking of erosion.

ii) To satisfy the demands of the right holders and of the local population generally

iii) To stock the understocked and blank areas and increase the percentage of valuable species in inferiority stocked forests.

iv) To attain as far as possible, the normal forests and to establish regeneration to the normal extent.

v) To manage the forest scientifically for the maximum production and sustained yield of timber fire wood and other raw materials obtained from forest and to realise maximum possible economic return from the forest land.

vi) To conserve the wild life and regulate the management of wild life in the forest in a rational manner.

1.2.7 The above two example vividly explains the choice of objects of management as per the local conditions and necessity within the broad frame work of National Policy.

1.2.8 Generally, the Working Plan envisages for the management of Government owned forest areas in which avowed objections of management figure. In case of recent concepts of wild life management, certain forest regions are earmarked as Sanctuaries, National parks, Marine parks, Biosphere, etc., for which separate schemes of management have to be prepared giving preference and priority to wild life preservation, maintena nce and improvement.

1.2.9 In the same way, " Social Forestry " is the latest concept and it is practised away from Reserved forests and the role of forester in that confined as a technical expert and advisor under a scheme prepared exclusively for that purpose. Here the owner the land may not be forest department but private individuals or institutions or semi or quasi-Government bodies, etc. Some of the areas belonging to the other wings of Government such as Public Working Department, Gram Panchayats, Railways, Highways may also be tackled under different names such as Farm forests, Extension forests, Avenue forests, etc., which require distinct scheming and planning combining productive as well as protective as well as aesthetic values as their objects of management.

1.3 Owner's attitude and Social role of Forestry:

1.3.1 As far as Indian forests are concerned major portion of forested areas is under the control of the Government. As per the Forest Research Institute Publication titled " India's Forests - 1980" the state owned forests constituted 95.8% in 1977-87 and the Corporate

bodies have 2.6% and private ownership accounted for the balance 1.6%. This happy position was due to (1) the inheritance of control of vast forest areas from the British Raj (2) Large scale acquisition of private forests belonging to erstwhile princely states, zamindars, etc., after independence. The ownership is very important for unfettered policy making, programme planning and schemes execution. When the ownership is with Government, the development measures can be undertaken and implemented systematica-lly. The attitude of Government of India over its forested area was first indicated in the 1952 National Forest Policy. After 25 years of experience on the implementation of that Policy, Government wanted to revise its forest policy and its attitude was revealed in the 1976 Report of NCA which formulated " three dimensional forests" viz., protection forests, production forests and Social forests which may reflect in the Revised Forest Policy to be declared, soon by the Government of India. NCA also recommended that " the production forests should not be permitted to be diverted to any other forest use" and " Resources for forest raw materials, both for internal consumption AND MATERIALS, both for internal consumption and export should be stepped up through large scale industrial plantations. An adequate investment of capital in forest based industries should be ensured in keeping with the production forestry programme ".

1.3.2 The Central Government's attitude on its forests has gone a drastic change recently, and it does not want any more inroads reducing the forest extent (We have lost around 4.2 million ha. of forest area in three decades) and promulgated a Central Act called " Forest Conservation Act, 1980" through which the alienation of forest areas for non-forestry purposes (both public and private) without the prior permission of Central Government is forbidden.

1.3.3 With regard to private owner's attitude, their profit motive has to be regulated so that the indiscriminate exercise of individual rights may not prejudice or endanger general welfare. Many states in India have enacted laws for the protection of private forests, restricting and regulating the exercise of the rights of the private owners.

1.3.4 Social Role of Forestry: More emphasis is now given to this " hitherto neglected " Social significance of forestry. Modern logging, modernised logging industry, Forest based industry oriented developmental activities in forests now generate more employment to more number of people especially hill tribes and forest villagers. It is expected during the Sixth Five Year Plan period Forestry and Logging will provide employment for about 7.8 million standard persons per year in 1984-85 an increase of 1.6 million standard person per year against the figure of 6.2 million standard persons per year in 1979-80. Thus it is expected to provide succour to the millions of people. In this connection, the noteworthy achievements in this respect by the Forest Development Corporation of Maharashtra is a good pointer.

1.3.5 Apart from these direct benefits, the Society needs some marginal lands for the purpose other than money value in the form of Recreational forests, the insurance against environmental pollution, etc.

1.4 From the above discussion, it is clearly understood that the task of Forest Management is a complex and peculiar one. As Meyer put it," the task of Forest Management must be to look ahead and reach conclusions, based as they must be on technical knowledge, which only events in the future will justify. This calls for judgement

of the highest order. A mistake made now cannot be corrected easily. But the task of Forest Manager challenges his competence in planning and execution".

1.5 The subsequent chapters will be dealing with the management concepts of productive forests only with economical under-current. Moreover, the timber and fuel wood production and harvest is the main theme of the study. In recent years, the production of " Industrial wood " is also to be considered as the dependence of many an industr rests on raw materials from Forests for e.g. paper and rayon, pulpwod,

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CHAPTER - III

SUSTAINED YIELD

1.1.1 Since the forestry sector is now an integral part of National economy, its management is to be planned in such a way to put forests into rational use through economic and scientific silviculture contrary to more exploitation of available natural growth. Besides, forests are now valued not only for its benefits but also for its economic returns to the national exchequer. Compared to the developed countries, Forestry's contribution to GNP (Gross National Products) in 1969-70 was the meagre 1.6%, which has to be increased considerably, for which there is vast scope and great potential present.

1.1.2 For the purpose of management, forests can be likened to agriculture. As in the case of agriculture, Forestry is based on the primary use of the land surface and consisting of three-fold activities viz. 1) control of growing stock, its composition and structure, 2) sales and distribution of products and 3) operational efficiency (L.C. Sharma 1980).

1.1.3 Forests are also compared to industry also. Investment of capital, production of commodities and marketing them profitably are the characteristics of industrial management. The same are applicable to Forestry also though the capital and product cannot be distinguished in case of Forestry. Again the long gestation period for getting yield and the complexity of forest crops which grow at different rates within a given area itself are the problems faced by Forest manager. Anyhow forest management for the past many centuries was able to tackle all such intricate, complicated problems through a celebrated but much criticised " principle of sustained yield ".

1.2.1 History of the principle of sustained yield:

It dates back to the end of 18th century and has its origin in Europe only. The intermittents wars between different kingdoms in Europe heavily costed the wealth of forests and therefore, a need arose for proper preservation and management of forests. In the middle of 16th century itself (Ordinance of 1544 of forests), France experimented on new methods called " Tire et Aire ". This means that the coupes of the year, selected by area i.e. equal area (couper a' aire), must have at least one boundary continguous and coincident, i.e. adjoining to the previous coupe (Coupe a' tire) and this method was called " Tire et aire". This method produced age gradations in a compact block and was applied to high forests of oak and beech. Later, in 18th century, in Germany, three Foresters, Ottelt, George Hartig and Heinrich van Cottoc propounded a new theory to provide sustained yield from their forests. Thus this principle of sustained yield was delivered to the forest world. The present day modern forestry is managed either under " Principle of Sustained yield " or under the latest concept of " Multiple use of forests ". This latter concept will be dealt with in the last Chapter.

1.2.2 Definition: According to FRI Glossary, Sustained yield is defined as " the yield of timber or other produce from a forest which is managed in such a way as to permit the removal of a maximum and

approximately equal volume or quantity of timber or other produce annually or periodically, in perpetuity.

1.23 Meaning of the concept: This concept envisages in the first hand " maximum " yield. This underlines the proper use of land capaility. As already explained, forestry is based on the primary use of land surface. This "maximum" can be obtained by high degree of operational efficiency i.e. adroit administration of property, personnel and finances coupled with the proper manipulation of Growing stock by means of correct choice of species, with reference to their site adaptibility, timely exploitation, adoption of Right type of regeneration methods coupled with better protection against injurious agencies. So the achievement of " maximum yield " in a given site is the first goal of the theory.

1.2.3.1 "Then, the concept expects " approximately equal volume or quantity annually or periodically from the given site apart from "maximum yield". Since the forest potentiality even in a compact block will vary due to the presence of "fertility gradient", "equal volume or quantity in the equal area annually " is impracticable. So it expected "approximately" equal volume or quantity. Moreover, due to the long gestation period the forest crop requires, it is subjected to various risk and hazards of Nature which may diminish the quantum of yield at thetime of harvest and so obtaining always " equal " volume cannot be assured and so only " approximately equal " volume is expected.

1.2.3.2 The words " annually or periodically " are also conveys significant meanings. Again due to the risks involved during the comparatively longer period of the forestry crop, chances of getting maximum and approximately equal volume every year will again not possible. So, the yield is reckoned for every year or for a block of period say for every 5 years.

1.2.3.3 The word " in perpetuity " is the most celebrated as well most criticised portion of the principle. The protagonists of this theory argues that this condition gives rise to many an advantage especia-lly in preparing the budget with confidence, assuring the continued supply of materials to the consumer industries, guaranteeing sustained work for the labourers, systematising the forestry operations, increasing the efficiency, perfecting technique, etc. According to them, it gives the best social results, best investment and the safe and most efficient management.

1.2.3.4 The opposite view is that, the words " in perpetuity " and "approximately equal volume"every year represents the "static" character of the principle in a dynamic world. With the advancement of scientific development in forestry, the narrowing gap between the point of production and consumption due to quick moving communication convenience, the need for increasing the per capita value of the forests and to meet the increasing demands of exploding population and growing industries, require a change in the concept.

1.2.3.5 Concept discussion: The principle of sustained yield relates to the both categories of productive forests namely (a) Naturally regenerated forests and (b) man-made or artificially regenerated forests. Its application is quite simple and easy in the latter case because such forest consists of Single species with single rotation period, having series of age gradations. But in the case of first rotation period when a natural forest is cleared and afforested, we can expect

neither any yidd nor sustained yield but sometimes good yield from valuable species extracted, if available. For e.g. (a) in case of grass land afforestation, in the period of first rotation, no yield can be expected (Wattle & Bluegum areas of Nilgiris and Upper Palnis).

(b) In case of degraded forests, some yield will be available from the cut materials of such forests in the first rotation period (e.g.) most of the dry areas taken up for Eucalyptus tereticornis, planting.

(c) In case of natural forests, taken up for Teak cultivation or Rubber cultivation in Tamilnadu, the area contained valuable moist or mixed deciduous forests which yielded good revenue.

In contrast, in the case of naturally regenerated forests, the application of Sustained Yield in the first rotation is complicated and complex due to the following inherent negative factors present:-

(1) The forests are irregular, unevenaged and various species mixed.

(2) The multiple score of species will have different maturity periods and so require different rotations.

(3) No age gradations can be present but age classes may be available but there is no guarantee for "even distribution " of such age-class.

(4) Here also the yield from first rotation period cannot be "sustained one".

1-2-3-6 So the application of the principle in different types of forests is done by adopting different silviculture systems as explained below:

(a) In case of irregular forests (mostly protective forests where also some yield is expected), the "selection system " is adopted. Here neither age gradations nor age classes are possible but for yield regulation, the "exploitable " dimension especially " girth " is taken into consideration, and the annual yield is fixed.

(b) In case of naturally regenerated productive forests, the principle is applied through "UNIFORM" system wherein "age classes " are created introducing " Periodic Blocks".

(c) In case of artificially regenerated forests, clearfelling system or coppice system are employed and thereby, a series of age gradations are easily created.

While considering this principle, it shall always be remembered that this theory holds good for any SINGLE species only and cannot be followed for more than one species in the same area. Moreover, the principle covers not only the volume of the produce but also its form and value. By the term " form" we mean, it conforms to the market requirement such round timber, bulked or squared or converted materials and by the word " value " we mean its " Price " which is always fluctuating and never stationery. The greatest handicap is that the yield and value cannot both be sustained at the same time, because the value depends mainly on the status of demand, production and supply of the produce.

1.2.4 For the successful implementation of this principle, there shall be favourable factor present and they are summarised as follows:

(a) Working capacity and productive capacity of the area shall be conducive or proper. These factors shall be identified and analysed and proper treatment prescribed.

(b) Sound silvicultural practices shall be formulated with proper infra-structure and pre-conceived estimate for systematic and timely carrying out of such practices without default. A-ny omission or delay in the systematic working cannot be rectified later and the consequence at the later stage will nullify the principle's aim of expected yield.

(c) Assure adequate and proper forest protection measures against all injurious agencies is a must.

(d) Apart from all human endeavours, the nature shall also be favourable since the forest is "nature-oriented" and nature-dictated" venture, with added peculiarity of "long gestation period". In such long periods, availability of more favourable climatic seasons and less unfavourable seasons, will definitely help the attainment of the principle.

(e) Presence of proper adeq-uate communication i.e. transportation facilities i.e. easy accessibility, making every part of the forest area that bears merchantable forest produce accessible.

(f) Good and steady markets which warrant our sustained production without undue fluctuations, shall be available either locally, regionally or internationally.

(g) Equitable taxation policy by Government is another important economic factor which can help the principle. More and heavy taxes on forest produce will result in lesser consumption and consequent fall in demand.

(h) Instead of practising " Producer concept " i.e. the present forest practice of what is available is offered, the guaging of "USER" concept i.e. "what is demanded by user", is to be employed and adhered.

1.2.5 Advantages of the principle of Sustained Yield:

For more than two centuries, this principle is being followed in every part of the world in forest management. Especially when the forests are brought under man-made forests, this principle was the first and best choice. Moreover when the communication facilities were very scarce and the demand from market was only for conventional timber, small timber and firewood, it was found to be a very handy tool for forest manager. The major advantage which accrued on the adoption of this principle can be enumerated as below:

(a) Property is kept in tact for longer period i.e. in perpetuity. Any demand for forest area for any other purpose can be avoided successfully as the area is put under use permanently. So the "surface stability" is achieved.

(b) Consuming market is assured of sustained and regular supply of raw materials and other produce so that all forest based industries can survive without any difficulty and they can plan for continuous and regular production of finishing products and supply to the mankind.

(c) Government as well the industries using forest raw materials can pre-plan their budget quite confidently and efficiently, since the activities are systematised in advance and available for follow-up;

(d) Because of the regular anticipated production and supply of raw materials, the employment is provided continuously which is the major sociological benefit.

(e) Economically, the forest is considered as a "property" and "Capital Asset " and it is maintained well and only the "interest" out of it is enjoyed. This is the great achievement of the principle of sustained yield. All Schemes are formulated in such a way that only the "interest" is harvested and no erosion or eating away of "Capital" is permitted.

1.2.6 Argument against or objections against the principle:

As already discussed briefly in Chapter-I and in the earlier discussion on definition of sustained yield in this Chapter, recent developments happen in forest do putforth serious objections to this principle, some of which are genuine also.

The first objection is that under this principle, no yield or little yield is available in the first rotation period especially when the areas are brought under conversion through clearfelling system. Only in the second rotation period, the expected sustained yield can be achieved. This situation is natural and unavoidable, when economically valueless areas are afforested to make them economically viable pockets and the "wait" for 2nd rotation period shall not be taken as a defect. Because if no such action is taken, the area will remain worthless for ever. Besides, we cannot say that for the whole first rotation period will be blank because there are chances for "intermediate returns" through pruning, thinning, etc.

Secondly, it is objected that it is not dynamic but static because the principle aims only at "approximately equal volume " and should aim at " maximum " only. During this century, the demand for forest produce is increasing manifold. Apart from conventional demands, the industrial demand is the new development, the forest department has to encounter. So, it is argued that supply shall be in direct proportion to the increased demand. Then only the forest can be considered as a genuine economic enterprise.

Thirdly it is objected that there is alround scientific development through research and its application in forest sector which can facilitate more production in the same extent of forest area. Introduction of short rotationed forest growing exotic species, isolation of better strains of species for higher production, reduction of rotation age of conventional species through intensive silvicultural treatments such as heavy thinnings, elite thinnings, etc. are some of the armours of antagonists of the principle of sustained yield. In fact, the rotation of the following species in recent years brought down considerably so that productivity of land can be increased. For example, the

rotation for teak is reduced to 50 years from 150 years, Chir pine to 90 years from 120 years, Deodar to 140-150 years from 150 to 180 years, Fir to 90-134 years from 180 years, Semul to 32-50 years from 75 years, Sissoo to 50-60 years from 75 years and Eucalyptus to 7.10 years from 15 years.

Actually, these developments are new which were not existing at the time of the conception of this principle. There is some genuine force in this objection.

Forestry, it is argued that when the distance between points of production and consumptions has been reduced to the minimum due to improvement in communication facilities such as construction of roads, availability of fast moving trucks and railways, etc. In olden days, the local markets were the main consideration and now-a-days, the produce can be sold anywhere quickly and profitably and so the concept shall be changed to " increasing yield " that "approximately equal volume ". This argument is also a weighty one and to be considered in proper perspective.

In actual practice, the objections have been taken note of and all efforts are made to make an effective compromises. But it is impossible to consider the forest property as pure "economic entity" since it is equally important as "ecological and environmental" safeguard. Moreover, the peculiar "long await" or " long gestation period " coupled with the risks involved due to nature's and man's vagaries during its long lease of life makes the principle of sustained yield as the only insurance available now and for a long time to come.

1.2.6 Principle of progressive yield:

The other alternative put-forth against principle of sustained yield is the principle of progressive yield. According to this, yield shall be "progressive" or increasing in relation to increasing demands. This principle was based on

i) gradual evolution of economy.

ii) progress in silvicultural techniques and

iii) Technological proficiency.

And it aims at

i) increase in productivity of soil

ii) increase in productivity of crop, which are obtainable by

(a) silvicultural treatment,
(b) Careful tending including protection
(c) Changing the composition of crop and enriching the forest with valuable mixture.
and (d) through artificial regeneration, replacement of original inferior species, and

iii) Exclusion of blank and unproductive areas from estimation of cost per ha. i.e. only the effective area shall be taken for economic valuation.

1.2.7 Conclusion: The pros and cons of application of the principle of sustained yield is a good technical study for the prospective forest managers. Now, if we analyse the present working plans of various forest divisions in our country and working schemes of various forest projects and corporations, the principle of sustained yield form the basic foundation and effective compromises are nicely incorporated to cater the maximum possible economic needs from forests without destroying the "capital" which has to safeguard the ecological and environmental needs of the same mankind.

CHAPTER - IV

ROTATION

Definition: The Glossary of Technical terms of FRI defines rotation as " The planned number of years lapses between the formation or regeneration of a crop and its harvest".

Society of American Foresterdefines the rotation as " The period of years required to establish and grow timber crops to a specified conditions of maturity".

R.V.Bra snett (1953) defines as " The number of years fixed by the working plan between the formation or regeneration and the final felling of a forest crop".

D.R.Johnston, et al (1967) defines as " The interval between successive crop regenerations".

F.C. Osmaston (1968) defines as " The interval of time between the formation of a young crop by seeding, planting or other means and its final harvesting".

M.R.K.Jerram defines " The period which elapses between the formation of a wood and the time when it is finally cut over".

All these definitions point out the same meaning i.e. the rotation denotes the interval period between the formation a nd final cut of forest crop. This interval period is not a common one to all forests crops, nor for the same crop in different regions. Rotation represents a regulating factor in management of a forest crop. Essentially, rotation expresses the rate of growth of the crop to produce the desired size and quality of the crop. If we analyse the rotations fixed to various forest crops, we can see the following important points in fixing the rotation:-

(1) Rotation differs from species to species: It is not common to all species, because basically the rate of growth differs species to species. The purpose of the species also differ and the age at which particular species reaches the " utility " stage also differ. That is why monoculture is preferred for easy management of forest crop. Polyculture with the species of different rotations involve many hazards in treatment and harvest though it is useful under proper and fullest land use.

2. Rotation differs for same species from region to region:

This is another special feature. The growth of any crop depends mainly on the site conditions and climatic factors. These factors in turn, reflect in the rate of growth of the species. Some soil conditions limit the maximum growth of a particular species whereas better soil conditions allow maximum growth of the same species. On this basis, the harvesting age and the utility of the particular species are determined which naturally differs. For e.g. Teak is grown in some districts of Tamil nadu only for pole crop with 40 years of rotation, beyond which no appreciable increase in the rate of growth, whereas in Kerala, the same species is grown for " Timber " purposes with 60 to 70

years of rotation. In the natural Teak areas of North Kanara (Uthara Kannada - Dandeli), the rotation is fixed 100 years and timber is extracted, whereas in Allaplly natural teak areas, the species is harvested after 120 years. In the same Allapally region (Maharashtra), the Forest Development Corporation of Maharashtra is growing Teak for pole crop with 40 years rotation. So there is no sanctity that the same period shall be adopted for one species in all regions as rotation.

3. Rotation is not a permanent one for a species at or particular site and can be increased or decreased.

Even after fixing a particular rotation for a particular species in particular region, the same may be changed thereafter. The reasons may be economical or change of purpose or scientific advancement which accelerate the rate of growth. For example, the rotation for Teak in Topslip region was fixed at 100 years about 5 decades back aiming to achieve 5' girth and now the same girth is obtainable in 60 years due to advanced scientific treatment such as stump planting, closer spacement, frequent thinnings (heavy) which induced accelerated rate of growth in the species. Another example of economic necessity which reduced the rotation age is about Eucalyptus tereticornis in Tamilnadu which was originally fixed at 10 years and now even the 6th year plantations are felled and supplied to paper factory. So, the rotation can be decreased. The increase in rotation is not popular because the economy wants quick and early returns from the forests. But in extreme cases of bringing normality to an abnormal forests the rotation can be increased also.

4. Rotation may conform to " Maturity " of the species but it may not always conform to " Maturity".

Generally the maturity of the species is considered as one of the factors for fixing rotation. But there are chances that maturity is not the only factor to fix the rotation. The purpose of the crop and skill of the forester i.e. the quality of treatment he gives to the crop are more important than the age of the crop. Only on this, Biolley opined that there is no need to give more emphasis to age of maturity in fixing the rotation. Besides, the new role of forestry in the present day world, " economic rotations " are much favoured and in such cases " the maturity " plays only an accessory or secondary role. In case of selection forest, the word " maturity " is used for fixing Rotation. But essentially, it is not "maturity", but it is the "Exploitable size " of the tree rather than age.

Factors considered for fixing Rotation:

Various factors play important role in fixing the Rotation for any crop. They are discussed below;

(a) Owner's desire and his policy: Forests are considered now as an asset or a property. A property is said to be useful only when it benefits the owner. So the owner will try to formulate a policy to reach his object out of his property. Forests can be owned by private individuals as well as by state. In different countries, the extent of ownership of forests both by private individuals and Government varies. In India, almost 96% of the forests are the property of the Government only. So the Government's desire is important. For which purposes, the Government wants to maintain the forests can be clearly seen from its policy. So the rotation has to be fixed to follow the Government policy or set guidelines to achieve the Government's desire or object.

Private ownership of forests in India is negligible (1.6%) and their main aim is to get maximum benefit out of their property. Only a very few private forest owners think about the systematic management.

(b) Financial aspects: Forests are considered as a property. And if forests are handled as " business enterprise ", it becomes the " CAPITAL ", in economic sense. When it is considered as a capital, it shall give economic"returns". These economic returns may be compared to " interest " accruing on the capital. So Forest owner expects the maximum interest. To get this interest, he has to maintain the forests, treat and tend the forests, protect the forests, and harvest the forests in a profitable way, for which he has to incur lot of expenditure. For these purposes, how long he can wait to harvest and when the harvest will bring him maximum revenue are the important factors. The period of wait and the time (age) of harvest are, only forms the " Rotation ". So, in fixing rotation the property owner's financial bearings are very crucial. Nobody will be willing to wait for a longer period and so longer rotations are ordinarily avoided. Shorter rotations and speedy and quick economic returns are generally favoured.

(c) Productive capacity of land and Tree species:

In forests, the land is the basic component of the "Forest Capital ". The other component is the " Tree species ". Unless the basic component is fertile the other component may not bring any appreciable result. So, in fixing the rotation of a particular species, the capability of the land shall also be taken into consideration. Besides, unlike shifting cultivation (where when the crop starts failing, the land is abandoned and new area is sought for), the " surface stability" of land is very important and hence, it shall be analysed how long the land will be capable of good production, and how many rotations it can withstand, etc.

So also, the productive capacity of tree species selected for the particular site, shall also be considered. Our aim always will be the maximum possible production for longest possible periods. Most of the species may not show increased rate of growth after certain age and sometimes the quality may suffer beyond certain stage. So, the rotation has to be fixed to the appropriate age and size. For e.g., it is said in Allapally (Maharashtra) that natural teak trees after reaching 120 years, if not harvested, immediately develop hollowness. In Upper Palnis and Nilgiris, the Wattle species develop gummosis after 10 years, then the quality of wattle bark considerably brought down. In the same way, *Eucalyptus tereticornis* suffers Gummosis after 10 years. Therefore, the rotation shall not reach that negative stage and be fixed quite before that eventuality.

In this connexion, another silviculture character of the concerned species also has to be taken into account i.e. coppicing capacity. All species are not good coppicers. Some species coppices well in particular age and beyond looses that power. When such species are selected as the forest crop, the rotation period has to be fixed coinciding the age at which the coppicing vigour is at its best so that the production will be maximum.

(d) Market demand for particular "forms".

In olden days, whatever was offered from forests were simply

taken and consumed by market. Now the situation is completely changed. Any material will fetch highest price when it is offered in the " form " in which the market demands. So now the market decides the "supply" and the producer shall take cognizance of the demand of the market. So the rotation shall have to be fixed to that age at which the required form " is obtained. For, electric transmission poles are the demand of the market means, the Casuarina can be supplied in 8th year, Eucalyptus globulus can be supplied in 10th year. Tectona grandis can be supplied in 10th and 15th year. If the pulpwood is the demand, Eucalyptus globulus (Bluegum) is harvested in 10th year, Wattle is harvested in 8th year, Eucalyptus hybrid is cut in 6th or 7th year. Here the words of Craib are worth-mentioning. " The aim of silviculture is the production neither of the greatest volume nor of the largest size in a given time, but the production of material which will most suitably fit the demands of the market yielding at the same time the greatest revenue to the state".

(e) Value of wood products:

The peculiarity of forest enterprise is that " its long gestation period ". It makes estimation of the future trend, being difficult and complex. If we now plant a species for supplying particular form of product in 20th or 30th year, we may not know what will be the value of that product at that time. We do the planting, etc. expecting that at least the present value of such products may persist in 20th or 30th year also. If the value of such produce, at the time of harvest, has come down, the whole purpose of raising that crop for so many years may become an economical waste. But in actual practice, it is found, despite the use of steel, concrete, R.C.C., etc., the demand for wood and wood products is not diminishing because of its inherent positive characters and so we can safely and confidently embark on forestry projects. But it shall always be borne in mind that the project shall aim at such " form of wood product " which will always be in demand and according the rotation has to be fixed. " Demand fixes the value " is the basic economic canon.

(6) Capital Investment: As already said, now-a-days the Forestry especially forest plantations are regarded as economic entity and as such they are treated as " Capital" investment. Now-a-days extensive plantations are envisaged for which the budgetary allocations are found meagre and also cumbersome. To have financial flexibility and to raise finance, corporations have been formed and they are allowed to raise required funds through "Institutional financing " from Banks, foreign agencies, etc. In such cases, funds are borrowed as loan repayable with interest at the end of particular period. Then, the project evaluation includes the present net worth (PNW), Discount rate, Internal Rate of return (IRR), compound interest calculation, etc. Number of theories such as " Soil rent" theory, " Forest Rent theory ", Soil expectation value, etc. are also considered. In such cases, the rotation fixing has to take economic period in which the maximum revenue is obtained.

So, the determination of rotation is one of the most important factors in proper economic management and control of forests. The rotations once fixed are re-computed and revised if necessary whenever the working plans are revised.

Various kinds of Rotation:

For the academic understanding, rotations are classified

into various kinds. The difference in rotations are based on the objects of management and also of "necessity". They are as follows:-

(1) Physical Rotation
(2) Silvicultural Rotation
(3) Technical Rotation
(4) Rotation of maximum volume production
(5) Rotation of highest income
(6) Financial Rotation.

(1) <u>Physical rotation:</u> - It is defined as the " Rotation that conincides with the natural lease of life of a species on a given site " (BCFT). It means the trees or crop are harvested only on their death. Generally this is followed in case of Protected forests, Park lands. Avenues and In [illegible] " the [illegible] " is secondary.

Sometimes, in case of some valuable species such as Sandalwood, where the artificial reproduction is not a success and natural regeneration is badly affected by " Spike disease ", physical rotation is only followed. Another example is Red Sanders of Andhra Pradesh which is endemic to few districts of the State and its artificial regeneration is cumbersome and the natural/regeneration is hampered due to phenomenal " die-back" character. One more example from Uttar Pradesh is that the irrigated " <u>Morus alba</u> " plantations are worked when they dry out due to want of irrigation (Haldwani).

(2) <u>Silvicultural Rotation:</u> This is defined as " the rotation through which a species retains satisfactory vigour of Growth and reproduction in a given site " (BCFT).

From the definition itself, it is clear that this rotation pre-supposes the crops which are regenerated by (a) natural means, through natural seeding and dispersal and (b) coppicing. In the former case i.e. in High Forest System, the rotation depends upon the <u>production of fertile seeds</u>. The seeding starts at the earliest age and ceases at the very highest age. Just befre ceasing of such production, the crop will be harvested. Not only the effect of age but also the proper Silvicultural treatments such as tending, thinning, shrub cutting, control burning, etc. also influence the regeneration which in turn, the rotation. This kind of rotation is not followed in man-made forests because the inhibiting conditions of natural regeneration are absent. Improved seed source, successful elimination of biotic pressures in man-made forests, etc. make economic rotations possible.

In coppice system, this rotation depends on the <u>age</u> at which production of <u>Vigorous</u> coppice-shooting just to cease.

So, silvicultural factors play a prominent role in fixing the rotation in such forest, and it is known as Silvicultural Rotation.

(3) <u>Technical Rotation</u> is defined as the rotation under which <u>a species yield most material of specified sizes and suitability for economic conversion on special use.</u>

So, it means that the harvest is depended upon the form in which the market demands the forest product to suit specific purposes. <u>E.g.:</u> Mine props, Transmission poles, Scaffolding poles, pulpwood for paper/or Rayon, Railway sleepers, plywood (Veneer production), etc.

(4) The Rotation of Maximum Volume Production: This is defined on " the rotation that yields the greatest annual quantity of material or that which produces the greatest mean annual volume increment of wood".

This is the widely used rotation in almost all the countries of the world because it embodies the principle of sustained yield (maximum and approximately equal volume). Besides it aims at profitable extraction and sale of wood. It is found from analysis that the maximum volume production is achieved when the mean annual increment(MAI) of a crop (not individual trees) reaches the culmination point, i.e., the point at which MAI is the highest will indicate the largest volume per hectare per annum. Because, in a normal series of "r" age gradations of any area, say A hectare,

Annual yield per ha. = Volume of oldest crop

i.e. m.a.i. x r per ha.

Area felled annually $= \frac{A}{r}$ ha.

So, the annual yield from the annual area $= \frac{A}{r} \times \text{m.a.i.} \times r = A \times \text{m.a.i.}$

When m.a.i. reaches maximum, Area (A) being fixed quantity, the yield will be maximum. For easy understanding, substitute the following figures in the above equations: m.a.i. = 15 cu.m.

'r' = 10 years, A = 100 ha., then

Annual yield = m.a.i. x r = (15 cu.m. x 10)

Area = 100 ha. and Annual area $= \left(\frac{A}{r}\right) = \frac{100}{10}$

$\therefore$ Annual yield $= \frac{A}{r} \times \text{m.a.i.} \times r = \frac{100}{10} \times 15 \times 10$

$= A \times \text{m.a.i.} = 100 \times 15 = 1500$ cu.m.

(5) The rotation of highest income is the rotation that yields highest average annual net income irrespective of capital value of the forests.

In this case capital value of land or land value is not considered. Again, the rotation is fixed under following assumptions namely (a) the wood has same value whatever its size, (b) annual expenses do not vary with alterations in the rotation (These assumptions in actual case, do not hold good). Besides, the calculations are arrived at from money yield tables. The average annual net income is obtained by dividing the sum of all incomes minus the sum of all costs over one rotation, by the number of years in the rotation. This is represented by the formula:

$$= \frac{Y_r + \Sigma T_a - c - r \times e}{r} \quad \text{OR} \quad = \frac{\text{Receipt} - \text{Cost}}{} \; \frac{(Y_r + T_a) - (c + re)}{r\ \text{(years)}}$$

Where Y_r = Final yield on 1 ha.

T_a = Yield from 1 ha. thinned at each thinning period (a = number of thinnings)

c = Cost of formation of one ha.

e = Annual maintenance cost for one ha.

r = rotation years.

Example:

Y_r = (1000 cu.m. x Rs.100 = Rs.100000)

T_a = 25 cu.m. x 4 thinnings = 100xRs.100 = Rs.10000

c = Rs.1,200/- per ha.

e = Rs.200/- per year

r = 10 years.

$$\text{Then net income} = \frac{(100000 + 10000) - (1200 + 200 \times 10)}{10}$$

$$= \frac{110,000 - 3200}{10} = \frac{106800}{10}$$

$$= \underline{\text{Rs.}10,680/- \text{ per ha.}}$$

'r' is fixed when the net income as per the formulae is found to be maximum. In this case, no interest on revenue and expenditure is calculated. In the case of present day industrial plantations formed through borrowed money this kind of rotation will not be of any use.

(6) Financial Rotation: is defined as " a rotation determined by financial considerations, i.e., that yielding the highest rate of "interest". In other words it is the rotation which yields the highest net return on the invested capital. This is otherwise known as "Economic Rotation". In this case, all items of revenue and expenditure are calculated with Compound interest at an assumed rate at which the Government is able to borrow money.

This kind of rotation fixing is not applied to Natural forests because of the lack of knowledge/data regarding the age, growth rate, mortality, etc. of the forest crop, the actual costs of various operations and the price range of end products.

This is easily fitted to the management of man-made forests especially industrial plantation. The advent of forest Corporations brought prominence to this type. The economic principles are applied in this case. This rotation gives the highest net profit over and above a certain fixed percent, after allowing compound interest on all expenditure and income.

Determination of Financial Rotation can be done through several methods which do not give the same results. According to

different bases of calculations, the following methods are usually formulated:

(a) Based on Soil cost: In this case, soil cost and profits have to be discounted to the same time - usually the commencement of the rotation and then, the rotation which gives the highest discounted profit is the financial rotation.

(b) Based on Soil Expectation Value: Here, the Soil expectation (Se) value is determined for different rotations at a given rate of interest and whichever rotation gives the highest soil expectation value is regarded as financial rotation. Syn. PNW (vide Appx. 1 & 2).

(c) Based on Financial yield or Mean Annual Forest percent:-

The Mean Annual Forest Percent is the financial equivalent of m.a.i. It is arrived at by converting all incomes over the rotation to net annual return and discounting it to the beginning of the rotation, dividing it by the Capital producing this income and multiplying the result by 100. Syn. I.R.R. (Vide Appx. 1 & 2).

The last mentioned (5) & (6) kinds of rotation required to be studied against a general background of forest economics. For detailed understanding of Economic analysis on fixing "Rotation", please see Appendix 2, wherein the PNW, IRR and Forest Rent, etc. are explained. The latest tendency after the formation of forest corporations banking upon borrowed money, economic arguments are put forth frequently for the fixation of economic rotations. As Brasnett put it " Economic arguments, however, must not be allowed to dictate the adoption of a rotation which might endanger the productivity of the soil. This soil is the primary capital of a forest, but it does not appear among the mathematical expressions of the formulae of economics."

The same view has been strengthened from the conclusion arrived at by Shri M.M.Pant and M.Y.Ansari, in their article titled " The Concept of Forest Rotation " which reads as follows:

> " To what extent these estimates and the rate of discount employed are rea-listic will govern the rotation so determined. How authentic is our data collection process for various forestry operations is known to 1 all. Therefore, purely economic arguments ca-nnot dictate the adoption of a rotation. If this is done it might ultimately affect the productivity of the site . . . . Purely economic arguments may not have a substantial significance in pragmatic forestry particularly when we aim at environmental and ecological stability as our objectives".

Choice or determination of rotation:

For considering the choice of most suitable type of rotation. The following procedure can be adopted:-

(a) Determination of number of years which the particular crop will take to produce the required material (Marketability or utility).

(b) Consider the time of maximum volume production, silviculture and silvicultural treatments for the particular species.

(c) Calculate the financial rotation also taking into account the capital cost, years of waiting, intermediate returns through thinnings, cost of formation and maintenance, compound interest on the above and the net revenue.

(d) Remember the objects of management:

Then, if it is commercial forestry, the rotation shall be " a combination of technical and silvicultural rotation tempered by market demands and essential economic considerations.

Significance of the length of the rotation:

(1) Silvicultural, biologica-l and protective aspects of management favour long rotation.

(2) Poor soils or sites are characterised by slower growth requiring long rotation to attain the desired size.

(3) Longer rotations make the stand acts as land reserves and money reserves.

(4) Longer rotations are favoured in the case of amenity forests, park lands, recreational woodlands, Avenue (canal, road, Railways) forests, etc. which exist for their services rather than for their material goods.

(5) Long rotation in productive forests, results in decreased vigour in the crop and production of lesser quantity of seed which are negative results.

(6) Short and shorter rotations are financially attractive and favoured in commercial forestry (Industrial wood production).

(7) Short rotations are easily adoptable in case of fast growing exotic species rather than indigenous species.

(8) Under short rotation, soil is very quick due to repeated harest frequently and in forest plantations, increase of fertility throgh fertilisers is very expensive and uneconomic.

(9) Short rotation, again, cause considerable fall in quality of the stand and in the quantity of annual yield.

(10) Short rotations such as financial rotation will result in the elimination of large trees and big timber for which demand may contiue or reappear in future.

Conversion period is defined " as the period during which the change from one silvicultural system to another is effected". This definition can be elaborated still further that the conversion period is the period during which a forest which is irregular in its character, with abnormal distribution of age classes, is converted into a regular crop with more or less normal distribution of age classes. Therefore conversion period is indicated (1) where a cha-nge in the silvicultural system is contemplated or (2) where a fôrest is being brought under scientific management for the first time.

For example, in the pine forests of Himalayas, sometimes, mature and over-mature trees constitute 75% of the crop and there is deficiency of younger age classes. The large trees may not be able to stand for another rotation and so in a shorter period than rotation for the pine crop, they will be harvested and the area are better stocked with vigorously young crops. This shorter period is known as " Conversion " period.

Rotation & Conversion period compared

Rotation	Conversion period
1. Planned period which elapses between formation and final harvest of a crop.	1. Period during which the change from one Silvicultural system to another is effected.
2. In case of regular forests, fixation of Rotation is a must and compulsory.	2. In regular forests, there is no place for conversion period.
	3. It is always smaller than the period of rotation so that sacrifice will be minimum.

The main fact to be borne in mind that the greater the difference between the conversion period and the rotation, the greater the sacrifice and it becomes more difficult to bring the forests on to the rotation at the end of conversion period and so the difference is kept as low as possible.

CHAPTER - V

NORMAL FOREST

The idea of "Normal Forest " is utopian but it is necessary as a standard with which an actual forest can be compared and the deficiencies found in it can be brought down through sustained yield management. In fact, no undertaking can have absolute normality and more so with the forests, which is complex in nature and its treatment. Moreover the normality changes with the objects of management, silvicultural systems adopted, the rotation periods, etc.

Definition: BCFT (British Commonwealth Forestry Terminology) defines the normal forest as " A standard with which to compare an actual forest so as to bring out its deficiencies for sustained yield management; a forest which, for a given site and given objects of management, is ideally constituted as regards growing stock, age class distribution and increment and from which annual or periodic removal of produce equal to the increment can be continued indefinitely without endangering future yield".

The above definition clearly pre-supposes the principle of sustained yield to achieve " Normality". With slight modification FRI Glossary accept the same defintiion.

F.G.OSMASTON in his book " The Management of Forests " (1968) proposed the following defintiion:

> " Normal forest is that forest which has reached and maintains a practically attainable degree of perfection in all its parts for the full satisfaction of the purpose of management ".

Here, he has introduced the words " practically attainable " to exclude a theoretical perfection impossible to attain.

N.V.Brasnett (1953) states that " A normal forest is an ideally constituted forest with such volumes of trees of various ages so distributed and growing in such a way that they produce equal annual volumes of the produce which can be removed continuosuly without detriment to future production".

AsPer S.A.F. (Society of American Foresters), Normal forest is defined as " One in which growing stock is so distributed by size and age classes as to provide a sustained yield of nearly equal annual volumes through growth.

All these definitions hinges on the following basic factors which in turn visualise the Normal Forests.

(a) Presence of normal series of age gradations or age classes.

(b) Accrual of normal increment, and

(c) Having a normal growing stock.

So, a normal forests can be defined as " a forest which has a regular and complete succession of age gradations or age classes in the correct proportion so that annual or periodic felling of riped woods result in an equalisation of the annual or periodic yields " (Anon.).

Concept explained:

Since the concept is based on three basic factors mentioned above, we will discuss henceforth each of those factors:

(a) Normal series of age gradations or age classes:

This means " the presence in a forest in appropriate quantity, the trees of all ages from one year old to rotation age".

Age gradations are easily achieved in man-made forests where " the trees of each age occur in separate areas ".

In case of natural forests, age classes can be available or attained " when trees falling within certain age limit occur mixed together in the same area ".

In irregular forests, there will neither be age gradations nor age classes in proper proportions and distribution.

So, the major factor for normalcy is the proper distribution of trees of all ages. Again, the normalcy depends and varies according to the rotation period i.e. a Forest said to be normal under 50 years of rotation cannot be a normal forest either under 100 years or 30 years of rotation.

(b) Normal increment: It means the " best or maximum increment attainable by a given species per unit area on a given site".

Whenever we mention " increment ", it always denotes the "Volume increment" only, the product of height and girth increments. The definition is self-explanatory.

(c) Normal growing stock: It is " the volume of stands in a forest with normal age classes or age gradations and a normal increment".

When there are properly distributed age gradations or age classes available with normal increment, automatically we can obtain " Normal growing stock". On the other ha-nd, the presence of normal G.S. does not and need not necessarily imply a normal forests which will be explained later under " Abnormalities ".

When normality is rarely achieved, abnormalities are quite common. They are of four types as detailed below:-

(i) OVERSTOCKED: A forest may come under this category on two counts:

(a) When a forest past the age of maturity may have more volume per hectare than the normal, and

(b) When the rotation already fixed is reduced.

In both the cases, there will be surplus growing stock due to

excessive distribution of the older age classes. And this surplus has to be gradually removed to achieve normalcy.

(ii) UNDERSTOCKED: This condition may arise in three situations as follows:

(a) Due to the pre-ponderance of the younger age classes, the volume per hectare will be less than the normal.

(b) Due to previous mismanagement or bad protection, the forest may have poor density than the "ought-to-be" condition, and

(c) through the increase or extension of the rotation period.

This is countered or brought to a better situation by means of very conservative treatment i.e. extracting less than the "permissible" amount and thus building up a proper reserve of growing stock. The deficit can be remedied by adopting a longer rotation than the required.

(iii) Growing Stock Volume Normal but age classes abnormal: The whole forest may contain of single age class against the normal proper distribution of all age classes. This is the worst form of abnormality and conversion of such forest to normalcy is very difficult E.G. Sal Forests.

In this situation, suspending or interrupting of sustained yield may be necessary and sacrifice of material due to decay and unsoundness may be unavoidable.

(iv) SUB-NORMAL INCREMENT: This situation may arise due to the effect of fire, disease, etc., or because of poor density or due to excessive over-mature timber.

In these cases also it is difficult to bring about normalcy without sacrifice of material.

WHETHER NORMALITY IS ACHIEVABLE?

(1) Normality is purely an artificial conception but a necessary one designed to meet the peculiarities needs of forest management.

(2) No virgin forest is normal. It may either be over-stocked or under-stocked.

(3) The " Normality" as already said dependent on " rotation " and " system " adopted.

(4) Even for the same species in a given site and rotation, the normality will not be the same in case of an even-aged high forest, selection forest or a coppice forest.

(5) The nearest 'normality' is attained only in man-made forests.

(6) But it is the only basis for all methods of yield regulation.

CHAPTER - VI

ACTUAL GROWING STOCK AND ITS INCREMENT

As we understood already that the " Forests" is a capital in the economic sense. A capital shall produce "INTEREST". Unlike the other forms of capital, forest capital and interest are indistinguishable. The estimation of the stock available has to be done for effective management. Since the forest stock is one of " growing ", the actual growing stock has to be ascertained periodically. The growing stock is represented ordinarily by " Volume" only. As we studied in the previous Chapter, the growing stock is the product of age gradations or age classes and the increment. Here we study first about the INCREMENT.

(A) INCREMENT: It is defined as " the increase in growth in height, diameter, volume, etc."

It is obtainable for any given period by measuring the height, diameter, or volume at the beginning and at the end of the period.

For our purpose, increment always mean VOLUME INCREMENT only. Now we will deal with different kinds of increments.

(i) CURRENT ANNUAL INCREMENT: (C.A.I.) The accretion or increase in growth which takes place in one year.

(ii) PERIODIC ANNUAL INCREMENT: (P.A.I.) The average increase in growth which takes place in a given period, say 5 or 10 years.

Since annual measurements are very difficult in forest and impossible in practice, only P.A.I. is taken as C.A.I. and all the yield tables consider P.A.I. as C.A.I.

(iii) MEAN ANNUAL INCREMENT (M.A.I.): It is the average annual rate of growth upto any given date i.e. it is an average rate of growth representing the total growth or yield at a given age distributed or spread over the period.

(iv) FINAL MEAN ANNUAL INCREMENT (F.M.A.I.): This is calculated by dividing the sum of Final volume at the end of the rotation and intermediate yields from the thinnings, etc., by the rotation period.

Therefore,

(i) $C.A.I. = \frac{V_1 - V_0}{1}$ Where = V_1 is volume at the end of one year.

V_0 is Volume at the start of the year.

(ii) M.A.I. $= \frac{V_x - V_0}{x}$ When V_x is the volume at the end of x years

V_0 is the volume at the beginning.

(iii) F.M.A.I. $= \frac{V_r + V_i}{r}$ When V_r is the volume at the end of rotation.

V_i is the intermediate yield and

r is the number of rotation years.

The above types of increments are explained mathematically with an example:-

E.g. A teak forest of 40 years old has a volume of $255m^3$ (Final yield of stem timber) and at 41st year, $265m^3$. The rotation fixed was 60 years and the final yield was found to be $400m^3$ and intermediate yield accounted for about $300m^3$. Find out C.A.I., M.A.I. and F.M.A.I.

Solution:-

C.A.I. $= 265m^3 - 255m^3 = 10m^3$

M.A.I $= \frac{265m^3}{41} = 6.20m^3$

F.M.A.I. $= \frac{400m^3 + 300m^3}{60} = 11.6m^3$

The study of C.A.I. curves is interesting. The C.A.I. is small in the seedling stage, gradually rises, reaches its maximum and falls till it approaches zero or death occurs.

In case of light demanders and moderate shade-bearers, the maximum is reached when the height growth culminates.

In case of shade-bearers, maximum is attained several years after the culmination of height growth and after attaining maximum C.A.I. falls rapidly at first and then more slowly.

Relationship of C.A.I. and M.A.I. curves and its significance:

There is a definite mathematical relationship between C.A.I. and M.A.I. The curves drawn for different species conforms to the same type design which is another speciality. The following deductions can be found from the C.A.I. and M.A.I. curve:-

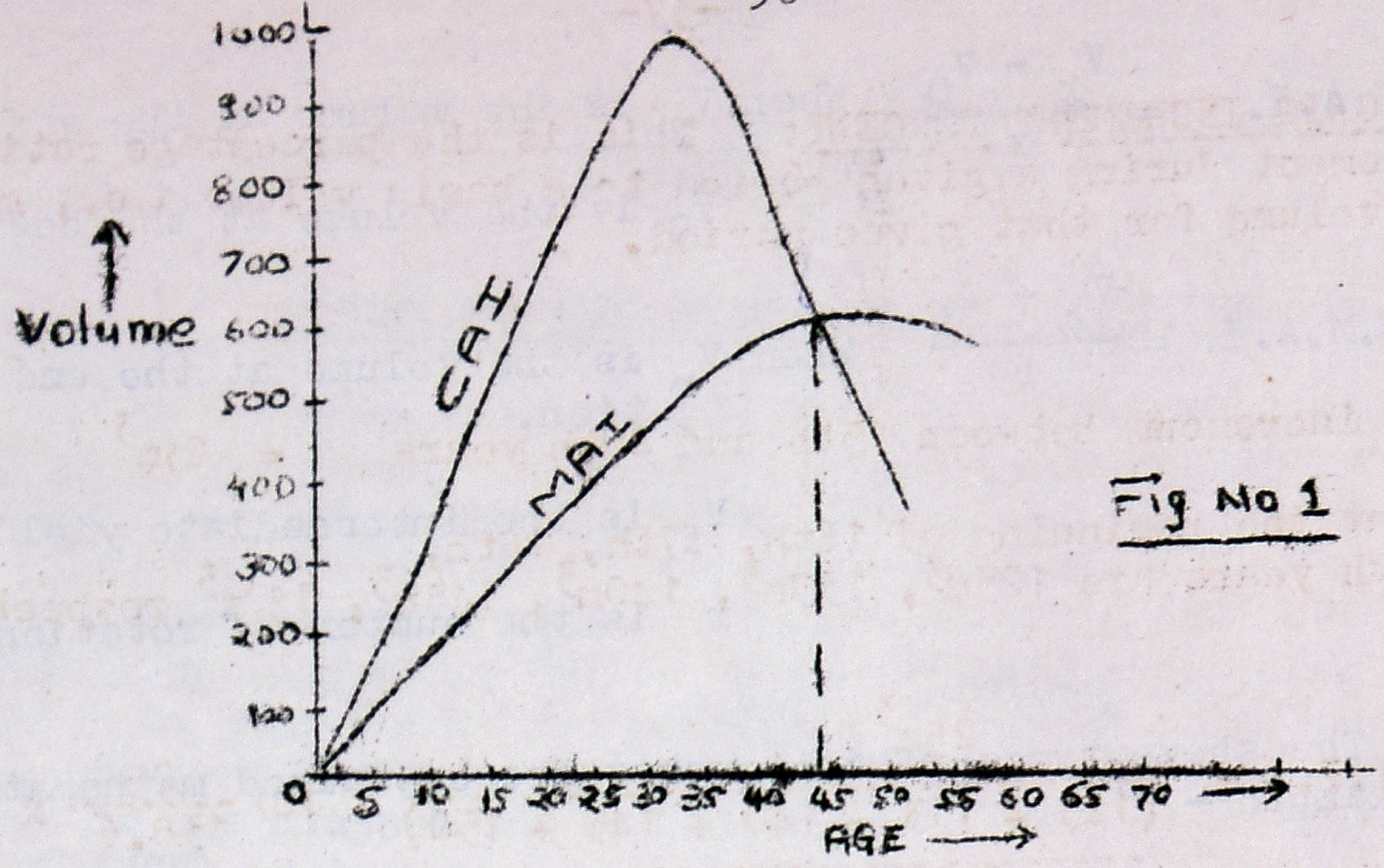


Fig No 1

(1) At first M.A.I. keeps below C.A.I.

(2) C.A.I. attains its maximum before M.A.I. and will be falling while MA.I. will be still rising.

(3) (a) Whilst C.A.I. is greater than M.A.I., the latter is rising.

(b) When C.A.I. is less than M.A.I. the latter is falling.

(c) When C.A.I.=M.A.I., the latter is stationary, and

(d) When C.A.I. and M.A.I. curves meet, the latter has attained its maximum.

The meeting point is of great importance in determining the rotation of Maximum Volume production.

Increment studies of individual trees cannot safely be applied to crops. The basic data for a study of crop growth should be a series of measurements on crops of various ages. The results of such measurements only are called YIELD TABLES.

INCREMENT PERCENT: This is defined as " an expression of the relation between increment and volume. In other words, it is the ratio of increment and volume expressed in percentage.

$$\text{Increment percent (I.P.)} = \frac{\text{Increment}}{\text{Average volume}} \times 100$$

It can be found out as in the case of increment for any period. So there are different kinds of increment percent as follows:-

(a) CURRENT ANNUAL INCREMENT PERCENT: It is the relation between the annual increase or increment during a given year and the volume at the beginning of the year expressed as percentage.

E.g.:- Volume at the beginning of 15th year = $125m^3$

Annual increment .. = $5m^3$

Then C.A.I.P. $= \frac{5}{125} \times 100 = 4\%$

(b) <u>PERIODIC INCREMENT PERCENT</u>: This is the percentage ratio between the increment during a given period to a basic volume i.e., mean or average volume for that given period.

<u>E.g.</u>:-

Periodic increment between 15th and 20th years $= 25m^3$

Volumes at the beginning of 16th, 17th, 18th, 19th, 20th years are $125m^3$, $133m^3$, $140m^3$, $145m^3$, $150m^3$ respectively.

$$\text{Then, P.I.P.} = \frac{25m^3}{\frac{(125 + 133 + 140 + 145 + 150)}{(5)}} \times 100 \quad \frac{25}{138.6} \times 100 = 1.8\%$$

(c) <u>MEAN ANNUAL INCREMENT PERCENT</u>: It is the percent ratio for which the mean annual increment for a given age bears to the total volume at that age.

<u>E.g.</u>:-

The volume at 51st year for a stand is $306m^3$.

Find out M.A.I. Percent:-

$$\text{M.A.I.} = \frac{306}{51} = 6m^3 \quad \text{Then M.A.I. Percent} = \frac{6}{306} \times 100 = \underline{1.9\%}$$

<u>Purpose of increment percent</u>:

(1) It is the indicator of maturity of either an individual tree or a stand.

(2) The decrease in increment percent indicates the maturity of the stand.

(3) When the increment percent becomes <u>lowest</u>, felling of the stand is indicated, yielding the <u>greatest possible volume</u>.

<u>How we measure the increment?</u>

Increment for individual trees can be found by (a) Stem Analysis, (b) using Pressler's borer, and (c) by repeated direct measurements periodically.

Increment for a stand can be found (a) from Yield tables (if available) and (b) by direct measurement of sample trees. Since all the trees in the stand cannot be measured every time, sample trees are selected and their volume and increment are taken periodically for arriving at the increment percent. The increment percent of average sample trees is often assumed to be that of the stand.

PRESSLER'S FORMULA FOR INCREMENT PERCENT:

We already know that

$$\text{Increment percent} = \frac{\text{Increment}}{\text{Average volume}} \times 100$$

If V = Volume at present, and v = volume at n years ago,

Then,

$$\text{Increment in one year or C.A.I.} = \frac{V - v}{n}$$

$$\text{Average volume producing the increment.} = \frac{V + v}{n}$$

Therefore,

$$\text{Increment percent, } P = \frac{\left(\frac{V - v}{n}\right)}{\left(\frac{V + v}{n}\right)} \times 100 = \left(\frac{V - v}{n}\right) \times \left(\frac{2}{V + v}\right) \times 100$$

$$= \left(\frac{V - v}{V + v}\right) \times \frac{200}{n} \quad \text{(Pressler's formula)}$$

E.g.:-

Volume of a crop @ 40 years = 200 m^3

Volume of the crop @ 50 years = 300 m^3

A thinning at 45th year yield = 20 m^3

Find out Increment percent:-

Solution:-

$$P = \frac{(300 + 20) - 200}{(300 + 20) + 200} \times \frac{200}{10} = \frac{120}{520} \times 20 = \underline{4.6\%}$$

Note:-

Volume for the purpose of finding out increment percent, the intermediate yield obtained through thinning shall also be included.

Pressler's formula requires calculation of volume of individual trees or stand that means, the measurement of height girth and form factor, etc., have to be taken which is a laborious process. Prof. Schneider developed a convenient formula in 1853 for finding out the increment percent. It is based on the determination of diameter at Breast Height and the number of rings in the last inch of radius as found by means of Pressler's borer.

Let D = Diameter at B.H., n = the number of rings in the last inch of the radius,

Then, $P = \frac{400}{nD}$ (Schneider's formula)

QUALITY AND PRICE INCREMENT:

Quality increment is defined as " the increment in value per unit volume of a tree or crop ". The value of the timber increases with the age and size. Larger sizes of timber always fetch higher prices due to increased utility.

Quality increment percent can be determined and expressed in the same way as volume increment percent by using Pressler's formula:

$$\text{Quality Increment percent} = \frac{K-k}{K+k} \times \frac{200}{n}$$

Where k is the value of unit volume rising to value K during the course of n years.

Price increment is defined as " the increment in price, independently of quality increment, resulting from fluctuations in the market on account of changes in money value in general and the demand and supply position in particular.

Price increment percent can also be determined in the same way as increment percent.

$$\text{Price I.P.} = \frac{P_2 - P_1}{P_2 + P_1} \times \frac{200}{n}$$

Where P_1 is the price of a unit volume of wood x n years ago and P_2, the present price.

EFFECT OF THINNING ON VOLUME INCREMENT:

It is generally found from the multiple yield tables for different grades of thinnings, there is practically no effect on the age when C.A.I. or MAI culminates. But heavy thinnings in previously neglected wood may result in checking the downward trend of C.A.I. and even second rise may occur as shown in the figure 2.

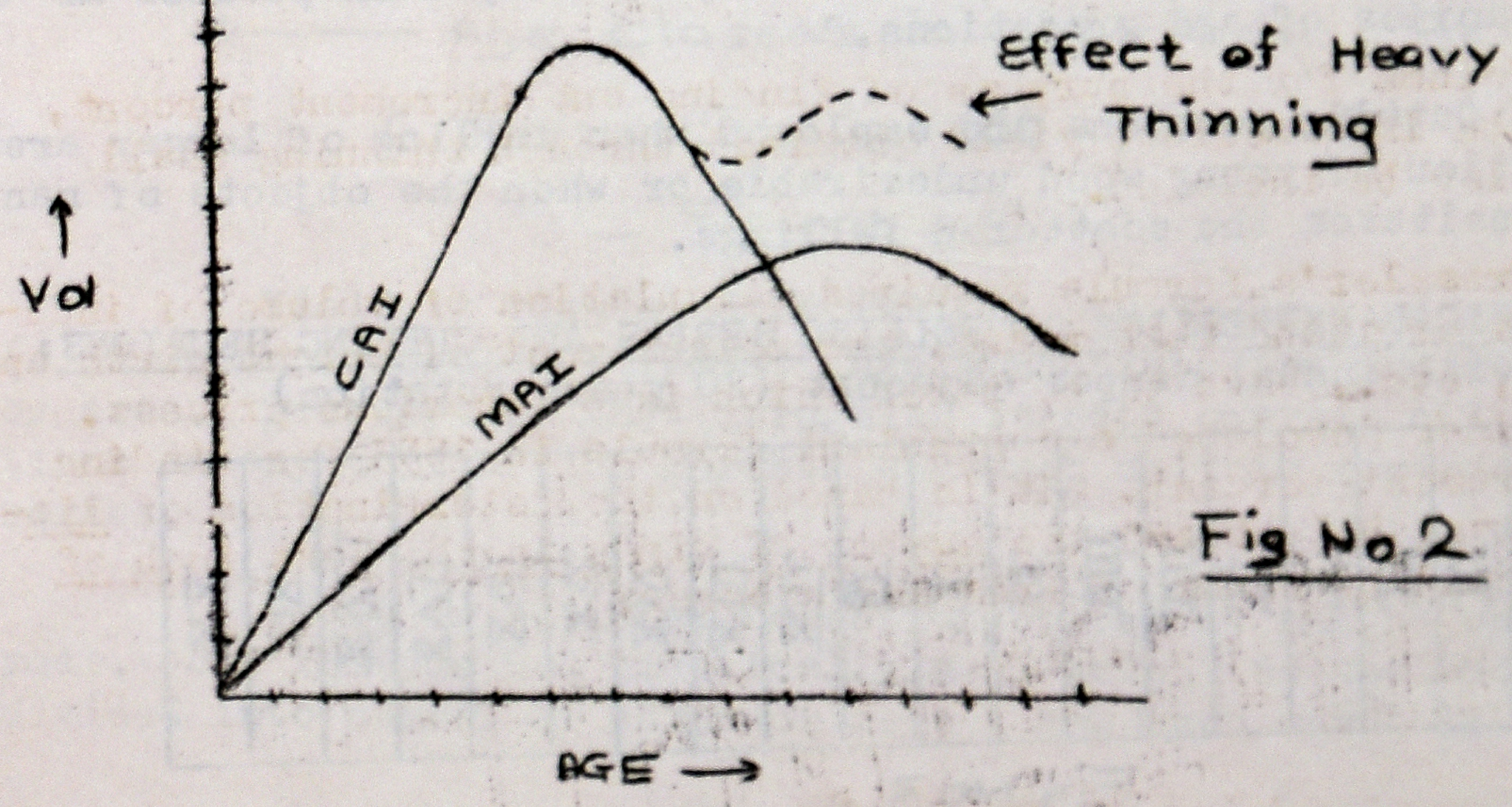


Fig No.2

(B) DISTRIBUTION OF AGE GRADATIONS OR AGE CLASSES:

Now we will discuss the second basic factor namely the distribution of age gradations on age classes next to increment which determines the growing stock.

For both the regular and irregular forests, the unit of yield regulation is FELLING SERIES.

FELLING SERIES is defined as " an area (forming the whole or part of working circle) containing or aiming at a NORMAL series of age gradations or age classes, with a separate calculation of the yield". So, a felling series is actually a sub-division of working circle.

WORKING CIRCLE is defined as " an area organised with a particular object and subject to one and the same silvicultural systems and the same set of working plán prescriptions". It may form the whole or part of a working plan area.

Now, we study the composition of "felling series" in regular and irregular forests under different silvicultural systems as detailed below:-

Felling series in (1) Clear-felling system (Regular Forests)
(2) Coppice system(Regular Forests)
(3) Regular Shelterwood system
(4) Irregular forests
and (5) Coppice with standard

(1) Felling series in clearfelling system: It consists of a number of ANNUAL COUPES which is equal to the number of years in the rotation fixed i.e. The total area 'A' is divided into 'r' years and so annual coupe area will be equal to $\frac{A}{r}$. Based on this condition only, the yield is regulated by AREA in clearfelling system.

It is not always necessary that annual coupes shall always be adjacent and they may be separated with a definite plan. This separation may be necessitated in view of insect damage or fire danger which may affect badly if they are contiguously situated. This kind of planned separation of annual coupes is known as CUTTING SECTION. It is defined as " the sub-division of a felling series formed with the object of regulating the cuttings in some special manners. But it differs from felling series in that they do not, each possess ~~or~~ a complete series of age gradations."

Cutting sections are employed when felling of larger areas and concentration of young wood undesirable or when the objects of management necessitates the scattered fellings.

DIAGRAMMATICAL EXPRESSION OF FELLING SERIES AND CUTTING SECTIONS:
(a) F.S. with annual coupes adjacent (20 years rotation).

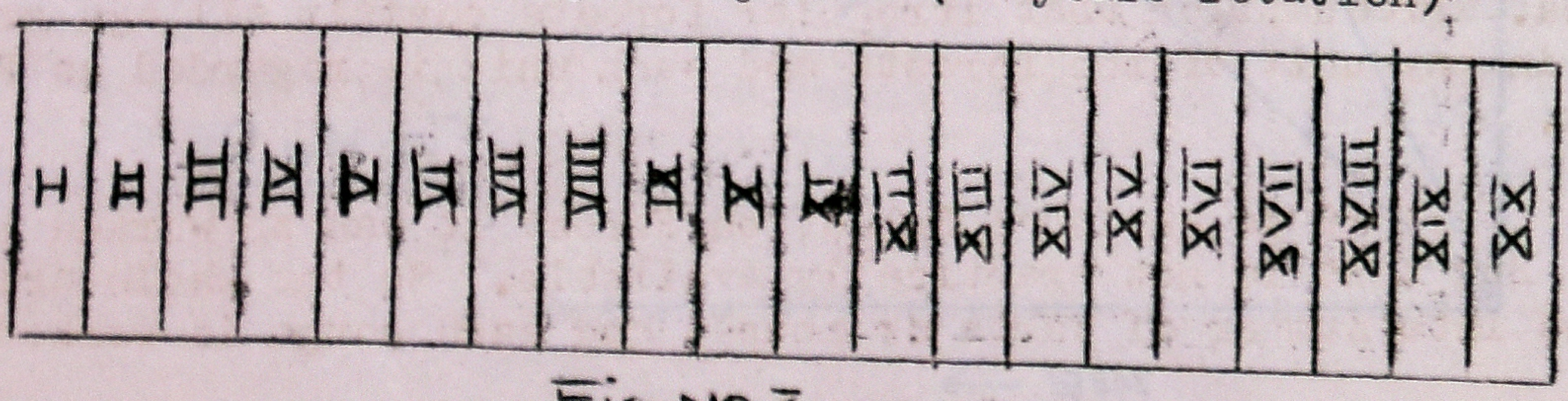


Fig NO 3

(b) F.S. in cutting sections with 20 years rotation (4 sections) Adjacent age gradations will have 4 years interval.

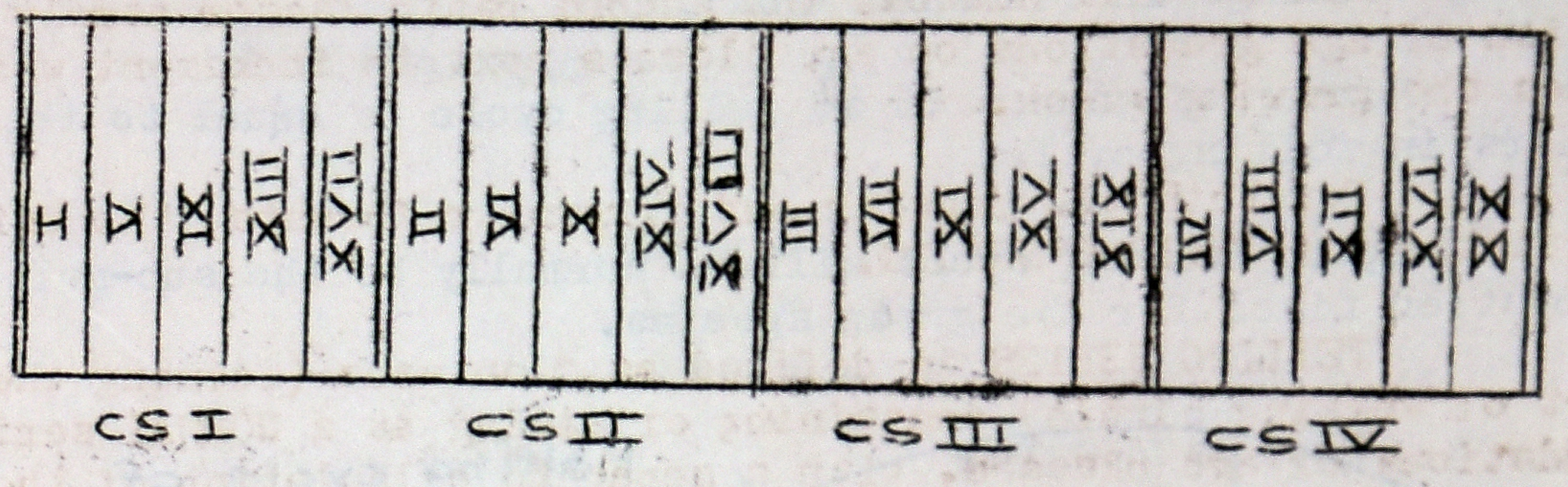


Fig no-4

The second method is also useful in (a) coppice system and (b) certain special cases of very rapid natural regeneration under a shelter-wood with slight modification.

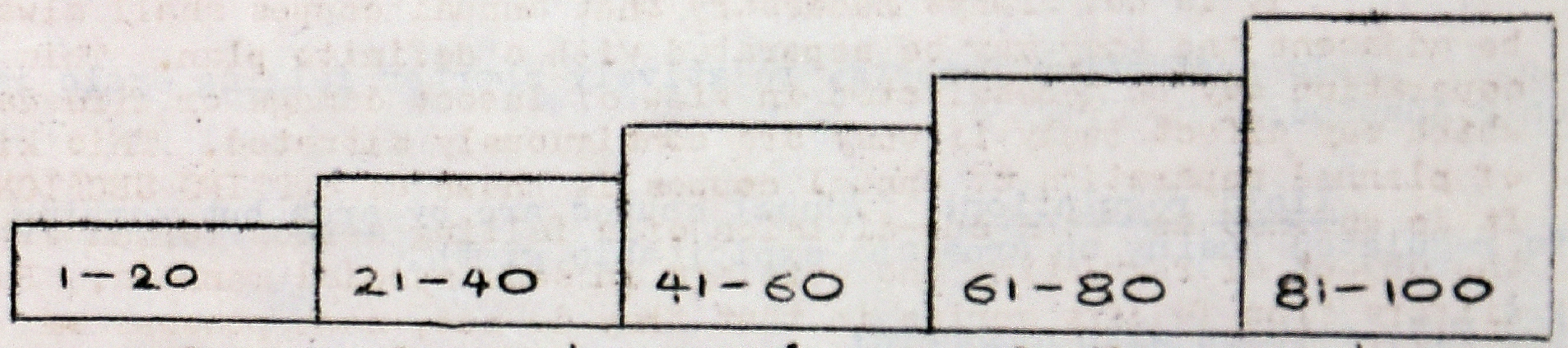
(2) F.S. in coppice system. The same as in the case of Clear-felling system.

(3) F.S. in regular shelter-wood system: Here instead of age gradations we will have Age Classes; in place of annual coupes, periodic blocks with regeneration period.

PERIODIC BLOCK is defined as " the part/parts of forest set aside to be regenerated or otherwise treated during a specified period".

Each periodic block is regarded as approximately even-aged.

The lesser the number of age gradations included in the age class in a periodic block, the more nearly it is even-aged.



← Age classes in periodic Blocks —

(Rotation - 100 years)

— Figure - 5 —

Yield is regulated by PERIODS and Volume and not by area.

(4) F.S. in irregular forests: Age gradations are indistinguishable by area. Presumption that irregular forests contain all age gradations in any unit of the forests and such unit is regarded as Felling series.

If it is an ideal Selection Forest it can be worked every year. But that is not practically available. So the whole area is divided into number of parts or coupes and each coupe is worked over

regularly at a fixed interval of years, called FELLING CYCLE. Felling cycle is defined as " the number of years elapsing between two successive main fellings in the same area".

Number of coupes in a felling cycle is equal to the number of years in felling cycle.

Again felling cycle will be normally be the sub-multiple of rotation fixed for the given species.

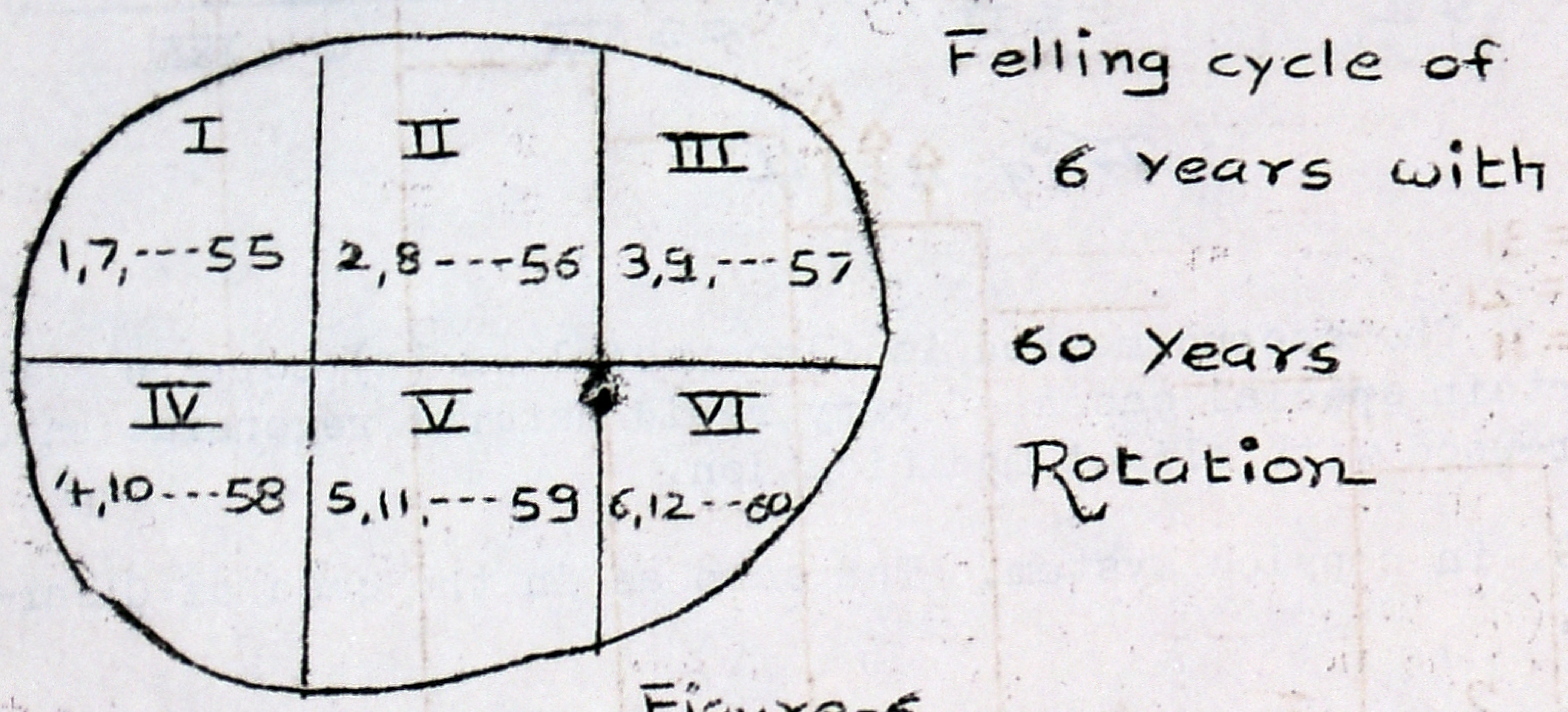


Figure-6

Characteristics of Felling Cycle:

The longer the felling cycle, the more intensive are the fellings.

The shorter the felling cycle, the lighter are the fellings.

Extremes: (1) If felling cycle coincides rotation period, it amounts to clear-felling.

(2) If felling cycle equals one year, coupe will be worked over every year and the irregularity is reduced to the maximum.

In protection forests, relatively shorter felling cycle is only adopted.

Yield regulation: Annual coupes are by area but working is regulated basing on area and exploitable girth.

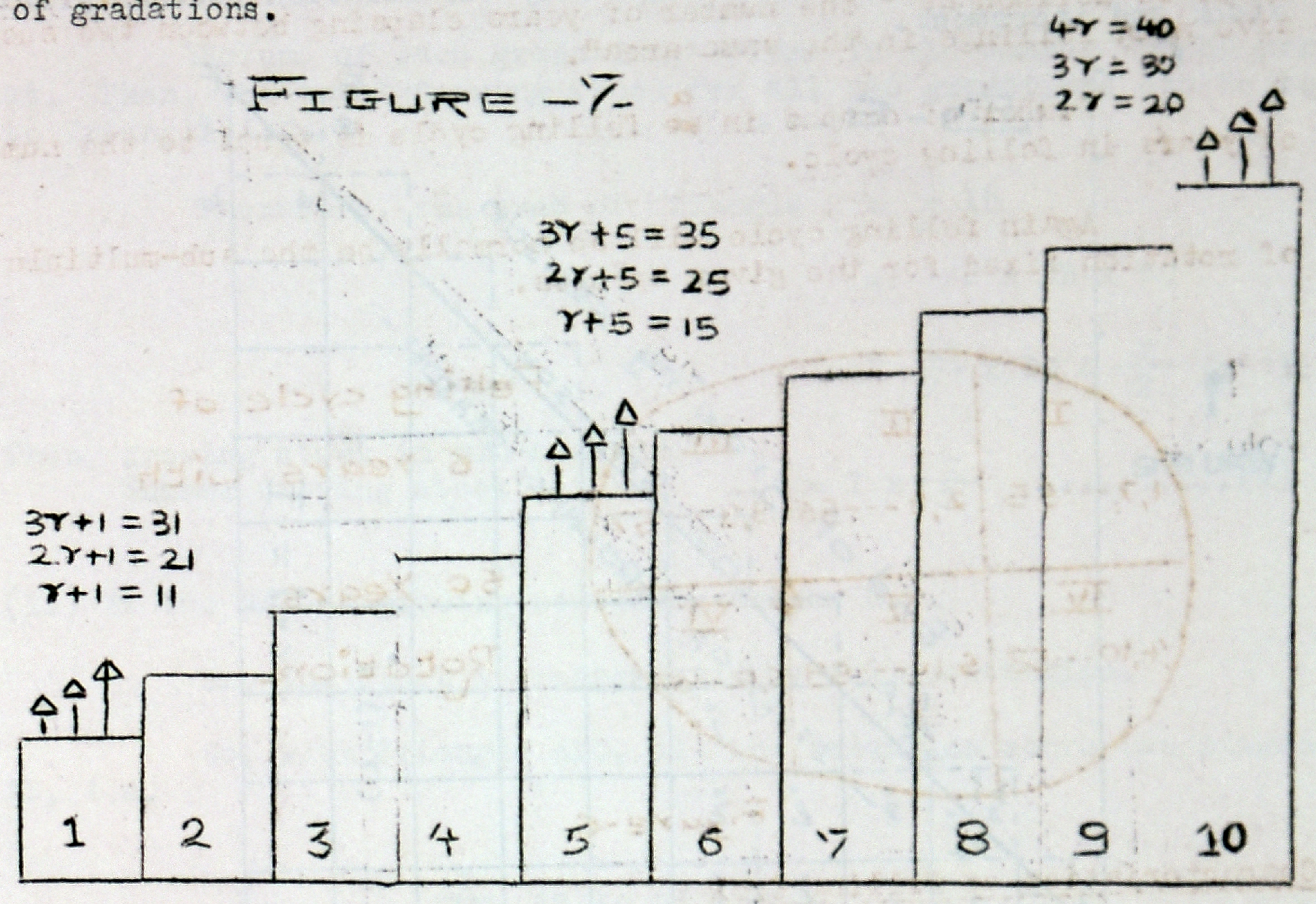
(5) F.S. coppice with standard:

For, Coppice crop, like clear-felling system. Yield regulation by AREA. For standards, yield regulation will be by number of trees arbitrarily settled, the number being progressively smaller, higher the age group, Coppice and Standards will have different rotation periods. Rotation of coppice will be sub-multiple of rotation of over-wood or standard.

E.g.:-	Coppice rotation	..	10 years
	Standard rotation	..	40 years

So far as the coppice concerned, there will be complete series of gradations.

FIGURE -7-



(c) NORMAL GROWING STOCK: This is the final condition or factor of " Normality", which is the automatic result of the combination of normal age gradations or age classes and normal increment. Already we have discussed about the different kinds of abnormalities found in actual conditions. It is the main job or object of forest management to remove such abnormalities and bring about at least " NEAR-NORMALCY". For this, the conception of Normal growing stock in every kind of forests whether it is regular or irregular, plantation forests or naturally regenerated forests, will be more useful in evolving suitable methods of yield regulation.

Now, we deal with the calculation of Normal growing stock. There are two methods for that namely (i) by calculation with M.A.I. and (ii) from yield tables.

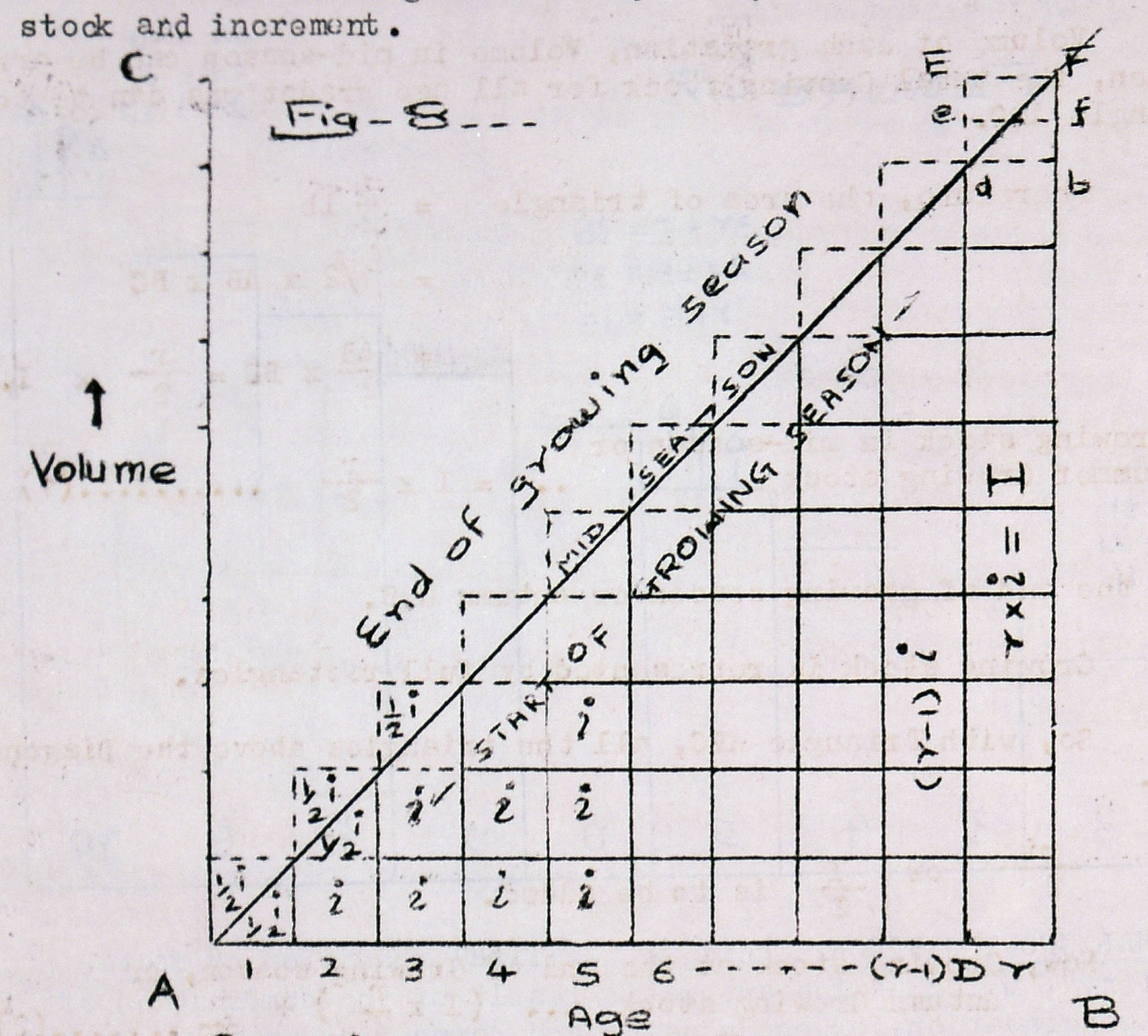
Calculation with M.A.I.:-

Let Rotation = r
'r' age gradations are available

M.A.I. = i per acre/ha and

ri = I(i.e.) One year old = i
2 years old = 2i
3 years old = 3i
(r-1) years old= (r-1)i
r years old = ri

Now we diagrammatically study the relation between growing stock and increment.



— Growing stock & Increment —

AB represents units of area occupied by an age gradation.
Each rectangle represents one year growth or increment = i

So, (1) the last age gradation (r) will have a volume = r x i = I.

We have already knew that,

(2) Volume of last age gradation = Final MAI x r years.

(3) Volume of last age gradation = sum of CAI of all age gradations.

(4) Volume = Total MAI of the series.

Then,

Annual yield of normal forest = the increment of the Forest.

In the above diagram, each rectangle represents the growing stock, <u>at the end of growing season.</u>

The line AF represents the mid-growing season.
Now consider the older age gradation = rectangle EdbF.
At the middle of growing season = 1/2 Edbf Rectangle adbf
= Triangle Fdb.
Total Volume of oldest age gradation 1 Figure FdDB.

In the same manner,

Volume of each gradation, Volume in mid-season can be arrived at. Then, the total Growing stock for all age gradations can be equal to Triangle ABC.

Therefore, the area of triangle $= \frac{1}{2}$ lb

$= 1/2 \times AB \times BC$

$= \frac{AB}{2} \times BC = \frac{r}{2} \times I.$

Then, Growing stock in mid-season or Summer Growing stock .. $= I \times \frac{r}{2}$ ....(1)

(ii) At the end of growing season or Autumn G.S.

Growing stock is represented by full rectangles.

So, with Triangle ABC, all the triangles above the Diagonal AB, i.e.

$\frac{ri}{2}$ or $\frac{I}{2}$ is to be added.

Now, Growing stock at the end of Growing season, or Autumn Growing stock ... $(I \times \frac{r}{2}) + \frac{I}{2}$ ....(2)

(iii) Growing stock at the beginning of the season or Spring G.S.

$= (I \times \frac{r}{2}) - \frac{I}{2}$ ....(3)

Notes:-

(1) For all practical purposes, only the mid-season or Summer growing stock formula is generally applied. All formula methods are based on Summer Growing Stock only.

(2) Assumption: Each unit area is putting on increment at an uniform rate or in other words CAI = F.MAI.

Mathematical Example:-

When the rotation is 100 years and the increment of the stand is $500m^3$, find out Summer, Spring and Autumn Growing Stocks:-

Solution:-

Rotation = 100 years Increment = $500m^3$

(i) Summer G.S. $= I \times \frac{r}{2} = \frac{500 \times 100}{2} = \underline{25{,}000m^3}$ Ans.

0 1 2 3 4 5 6 7 8 9 10 11 12

98 99 100 101 102

(ii) Spring G.S. $= (I \times \frac{r}{2}) - (\frac{I}{2}) = (\frac{500 \times 100}{2}) - \frac{500}{2}$

$= 25000 - 250$

$= \underline{22750\ m^3}$ Ans.

(iii) Autumn G.S. $= (I \times \frac{r}{2}) + \frac{I}{2} = (\frac{500 \times 100}{2}) + \frac{500}{2}$

$= 25000 + 250$

$= \underline{25250 m^3}$ Ans.

(2) <u>Calculation of Growing Stock from Yield Tables:</u>

When Yield tables are available for the species, the growing stock can be calculated mathematically from them as follows. In this connection, we shall note clearly that yield table does not give data for yearly interval but periodic intervals of 5 or 10 years only.

Let, 'n' be the yield table interval.

Let, A,B,C,D.....are volumes at the age of n, 2n, 3n, 4n, years.

The number of terms in each series will be n + 1.

Then, Average volume of each age gradation from Zero (0) year to 'n' years inclusive

$\frac{(0+A)n}{2}$ ∴ $\frac{\text{First point} + \text{last point}}{2} \times$ class interval, i.e. Av. x class interval

$$= (0 + A) \times \frac{n+1}{2}$$

Similarly, Volume for 'n' to '2n' years,

2n to 3n years, 3n to 4n years, etc. $= (A + B)\frac{n+1}{2}, (B + C) \times \frac{n+1}{2}, (C + D) \times \frac{n+1}{2}$

Summing up,

$$G.S. = (0 + A) \times \frac{n+1}{2} + (A + B) \times \frac{n+1}{2} + (B + C) \times \frac{n+1}{2} + (C + D) \times \frac{n+1}{2}$$

Since we have added the volumes of each series twice, they shall be deducted to get the Autumn G.S. (End season).

Therefore G.S. $= \frac{n+1}{2} \times (A + A + B + B + C + C + D + D) - (A + B + C)$

$= \frac{n+1}{2} (2A + 2B + 2C + D) - (A + B + C)$

$= (n + 1) \times \frac{(2A + 2B + 2C + D)}{2} - (A + B + C)$

$= (n + 1) \times (A + B + C + \frac{D}{2}) - (A + B + C)$

$= nA + A + nB + B + nC + C + n\frac{D}{2} + \frac{D}{2} - A - B - C$

$$= nA + nB + nC + n\frac{D}{2} + \frac{D}{2}$$

$$= n\left(A + B + C + \frac{D}{2}\right) + \frac{D}{2} \quad \text{......Autumn G.S.}$$

Then,

Spring G.S. (Beginning of the season)

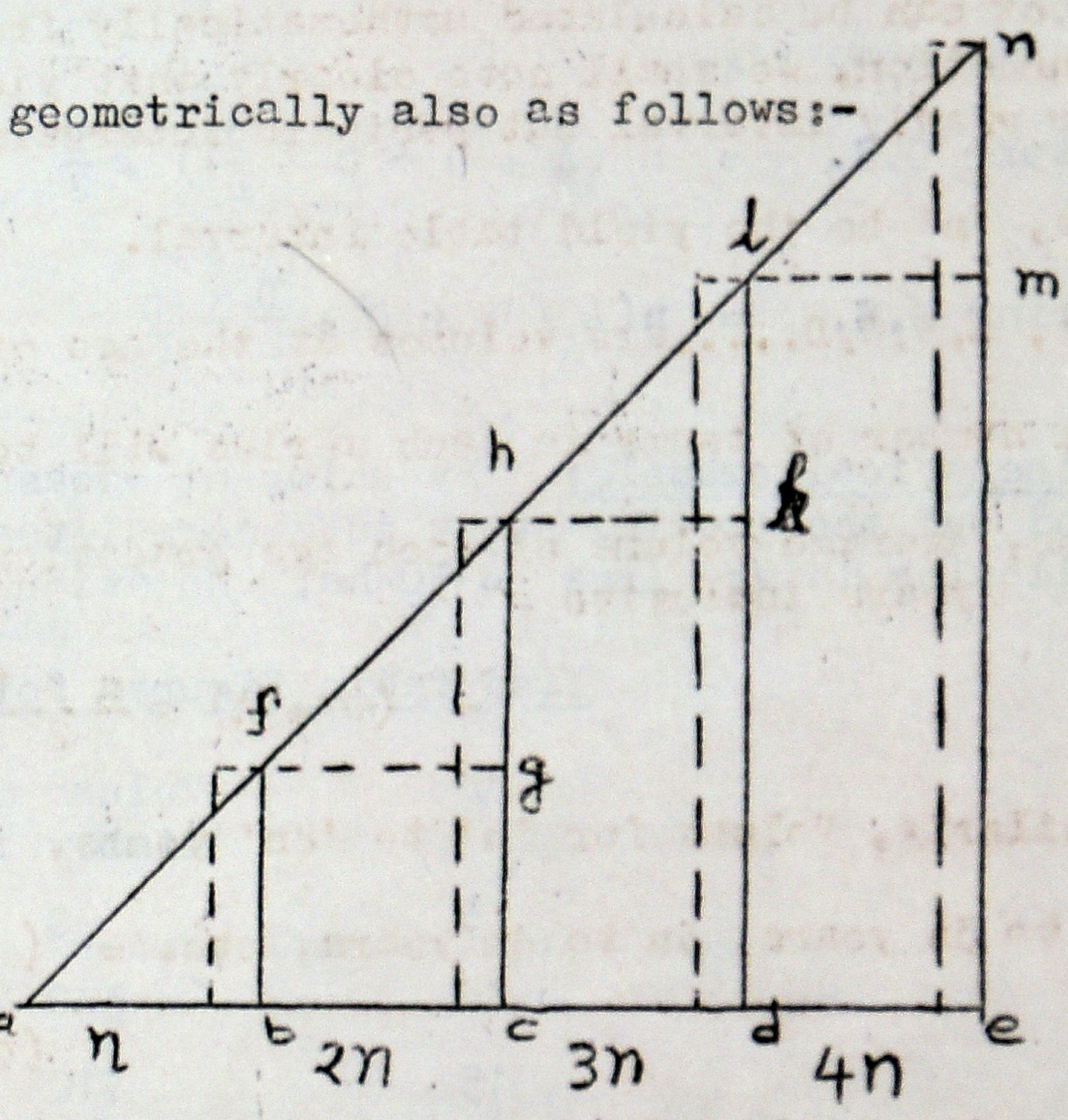
$$= n\left(A + B + C + \frac{D}{2}\right) - \frac{D}{2}$$

Summer G.S. (mid-season)

$$= n\left(A + B + C + \frac{D}{2}\right)$$

The same can be deduced geometrically also as follows:-

Fig-9 →



See the fig. 9 above. Assume a yield table showing only 4 entries at intervals of 'n' years. Let the volume at nth, 2nth, 3nth and 4nth years be represented by the rectangles A, B, C, D.

Then, the summer Growing stock for the whole rotation r = 4n on A hectares will be the sum of fig. abf, fbch, hcdl and lden. Now we calculate the area of the figures as follows:-

Fig. abf is a triangle and therefore, area $= A \times \frac{n}{2}$ ....(1)

Fig. fbch contains rectangle fbcg + triangle fgh and so its area

$$= nA + (B-A)\frac{n}{2} \quad \text{..........................(2)}$$

Likewise, Fig. hcdl = Rectangle + triangle hkl

$$= nB + (C - B)\frac{n}{2} \quad \text{..........................(3)}$$

Fig. 1den = Rectangle 1dem + Triangle 1mn

$= nC + (D - C)\frac{n}{2}$ ....(4)

Summing up (1) to (4)

$$G.S.\ (\text{Mid- season}) = (A \times \frac{n}{2}) + (nA + (B-A)\frac{n}{2}) + (nB + (C-B)\frac{n}{2}) + (nC + (D-C)\frac{n}{2})$$

$$= (nA + nB + nC + n\frac{D}{2})$$

$$= n(A + B + C + \frac{D}{2})$$

In the same way,

$$\text{Autumn G.S.} = n(A + B + C + \frac{D}{2}) + \frac{D}{2} \quad \text{and}$$

$$\text{Spring G.S.} = n(A + B + C + \frac{D}{2}) - \frac{D}{2}$$

<u>Mathematical example;</u> By using mid-season formula (Yield table), find out the growing stock in a normal teak forest of I quality, given following data: Area = 50 ha. Rotation = 30 years.

<u>Yield Table figures for 30 ha.</u>

Age	Volume of Stem Timber in Cft.
5	0
10	340
15	710
20	1160
25	1650
30	2180

<u>Solution:</u>

Mid-season formula $= n(A + B + C + D + \frac{DE}{2})$ where n is the interval.

Therefore, G.S. $= 5(340 + 710 + 1160 + 1650 + \frac{2180}{2}) = 5 \times 4950$

$= 24,750$ Cft.

G.S. for 30 ha. = 24,750

For, 50 ha = $24750 \times \frac{50}{30}$ = 41,250 Cft. Ans.

Comparison of Volume computed through Final MAI and calculated from Yield Tables.

The following figure will diagrammatically explain the two methods and compare them.

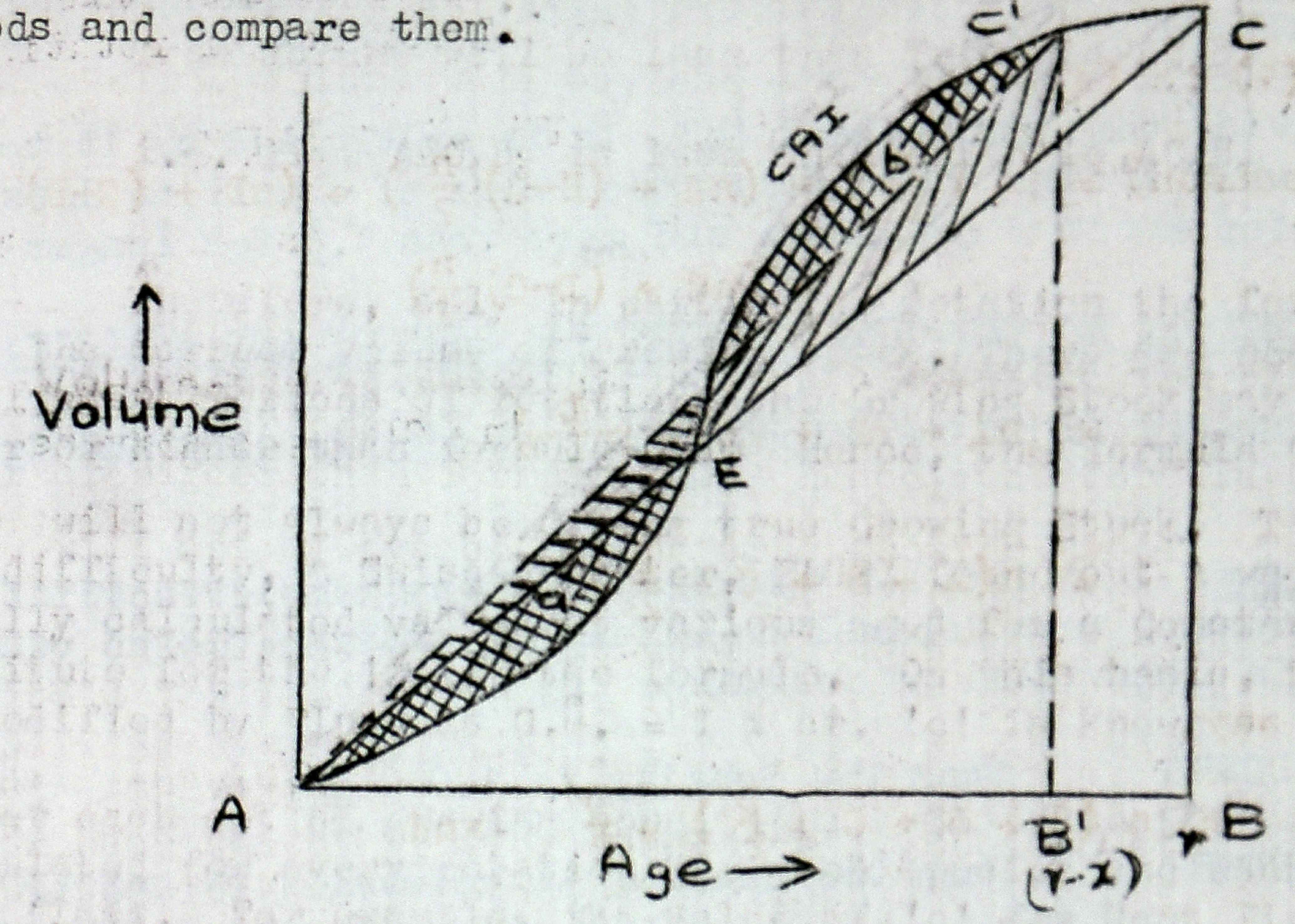


Fig 10

Straight line AC represents Volume based on MAI

Curved line ADEFC represents Volume based on Yield Tables.

At r years, Volume in both the cases are approximately equal.

i.e. Fig. AEC = Triangle ABC (Fig. (a) AE = Fig. EC (b)

But at (r x x)th year,

True Volume will be less than Triangle AC_1B_1

i.e. Fig. AEC_1B_1 is less than Triangle AC_1B_1

Therefore, only in particular rotation the formula method gives the correct volume of growing stock. There are cha-nces that in different periods of rotation, the Growing Stock may be either lesser or higher than formula G.S. Hence, the formula G.S. i.e. $I \times \frac{r}{2}$ will not always be giving true Growing Stock. To alleviate this difficulty, a Swiss Forester, FLURY found out a way out. He actually calculated values at various ages for a Constant 'C' to substitute for the 1/2 in the formula. On this basis, the formula was modified by Flury as G.S. = I x cr. 'c' is known as "Flury's constant". The value of 'c' vary for Each Species, for each rotation and for each set of growing conditions. So it must therefore, be ca-lculated for every rotation for each species and each quality or yield class. For example, the value of 'c' for Scot Pine was found to be 0.387 for an age of 60 years and 0.508 for an age of 120 years. Again the value of c varies from about 0.4 to 0.6 for common rotations of European species.

To determine this constant, normal yield tables are necessary, if they are available.

Then, $C = n \frac{(a + b + c \;.......\; 1/2)}{r \times I}$ This formula was arrived as follows.

$$G.S. = I \times cr \quad .... \quad \text{Formula method}$$

$$G.S. = n(a + b + c - 1/2)$$

Then, $I \times cr = n\,(a + b + c - 1/2)$, then $c = \dfrac{n\,(a + b + c - 1/2)}{I \times r}$

Having thus determined 'c', Ir is multiplied by it to get the correct growing stock. Generally, the value of c will be less than 0.5. for shorter rotations and more than 0.5 for longer rotations.

GROWTH ESTIMATION BY REDUCING FACTORS FOR DENSITY AND QUALITY:

Density is of two kinds namely Canopy density and Crop or Stand density.

Canopy density: Is defined " as the relative completeness of canopy usually expressed as a decimal co-efficient, taking Closed canopy as unity. It is classified as follows:

CLOSED	When the density is 1.0
DENSE	When the density is between 0.75 and 1.0
THIN	When the density is between 0.50 and 0.75
OPEN	When the density is under 0.50

CROP OR STAND DENSITY: Is defined as " the relative completeness of the tree stocking expressed as a decimal co-efficient, taking normal number of trees, basal area, or volume as unity. Here the terms over-stocked. Full or complete, and incomplete are used to describe crop density, according as it exceeds, equals or less than 1.0 respectively.

It is necessary that the sustained yield produced should be the maximum possible in a given site with a given species and for a given purpose. This means that from infancy of the stand, there must be fullest possible utilisation of the site. The index of full utilisation of the site is the presence of "complete" canopy.

In earlier stages many more trees form complete canopy and in course of time, the lesser number of trees form the complete canopy. If we look at yield table of any species, we can find out that number of trees per hectare very with the age, site quality and treatment, i.e., intensity of thinning. So, assessment of normality with number of trees will be misleading. So the comparison of basal area or volume of the age class or gradation with yield table figures will give true picture.

Reducing Factor: Where the several age gradations occupy separate ground, normality is ealy ascertained by finding the actual area occupied by such gradation, provided the density is normal throughout the area. If the density is not uniformly normal, a correction factor, called Reducing Factor has to be applied so as to convert all the areas to standard density. " The figure by which each class must be multiplied to reduce it to the standard is known as the Reducing factor and the area so obtained as the "Reduced Area".

Example: Species xx xx

Quality Class	Yield per ha. at maturity	Reducing factor	10 ha. of real area becomes in Reduced area
I	6800	$\frac{6800}{2000} = 3.4$	10 x 3.4 = 34
II	4200	$\frac{4200}{2000} = 2.1$	10 x 2.1 = 21
III	2000	$\frac{2000}{2000} = 1.0$	10 x 1.0 = 10
IV	1500	$\frac{1500}{2000} = 0.75$	10 x 0.75 = 7.5

Note:- The third quality has been taken as Standard.

From the above, 10 ha. of I quality is equal to 34 ha. of III quality; 10 ha. of II quality is equal to 21 ha. of III quality and 10 ha. of IV quality is equal to 7.5 ha. of III quality.

This reducing factor can be applicable only in the case of regular man-made forests whose age gradations are occupying separate areas. Whereas in irregular forests, age gradations are mixed where normality can be tested only by volume or basal areas and not by area.

Money yield Table: These are similar to volume yield tables in which yield is expressed in the form of money instead of volume. Money depends upon the volume obtained at any age (depending on the quality class) and price per cubic metre.

The quality class is determined from the height of dominant trees.

Price per cu.m. depends on the size of timber and its relationship is expressed by drawing a graph of the price per cu.m. of average tree. This graph is called price-size graph and the curve is called price-size gradient.

With the help of this gradient, volume table datas are converted in terms of money. Total value per hectare is found out by adding the values of all trees of different classes. These values are found out for main crop and thinnings.

Finally money yield tables data is tabulated in appropriate columns. A proforma of Money yield table is given below:

Age	Main crop						Thinnings		Final yield		
	No.of trees	Cu.m. total	Per tree	Price Rs.	Value	Value less 30 per cent	No.of poles or cu.m.	Rt or vol. per tree	Price	Value	Value
1	2	3	4	5	6	7	8	9	10	11	12

Note:- In case of Main crop value is reduced by 30% to compensate the loss due to fire, rot, pest or insect attack, wind damage, etc.

FOREST PERCENT: Investment on any enterprise should yield a rate of interest and then only the enterprise can be said to be economically sound. In the same way, investment made on Forest land should also yield proper rate of interest. This rate of interest is known as Financial yield or mean annual forest percent. It is calculated for the whole rotation period.

The purpose of this Financial yield or MAF percent is to find out most favourable financial rotation. For various rotations, the financial yields are calculated and the rotation which gives the highest financial yield can be selected.

In calculating the financial yield, the land value or soil expectation value is taken into consideration. The term soil expectation value was coined by a German Forester Mr. Faustmann. The whole expenditure comprising cost of formation, annual maintenance cost, all the income through main crop and thinnings done during the rotation period are taken into consideration with certain percentage of compound interest. The formula propounded by Faustmann reads as follows:

$$S_e = \frac{Y_r + \sum T_a \left(1.0_p^{\,r-a}\right) - C\left(1.0_p^{\,r}\right)}{1.0_p^{\,r-1}} - \frac{e}{.0_p}$$

Where

S_e = Soil expectation value.

Y_r = Value of final crop at rotation age.

r = Rotation

T_a = Thinning in 'a' year (if more than one thinning are conducted, income from each such thinning shall be included as T_b, T_c, and so on.

C = Cost of raising plantation (first 2 or 3 years)

c = Annual cost of maintenance, fire protection, etc.

P = the rate of interest (generally 2 to 6%)

NOTE: Fig 1 to 10 drawn by Shri B.T. WANKHEDE (1983-85)

CHAPTER - VII

REGULATION OF YIELD

Definition: Regulation of yield means the determination of yield (i.e.) the amount of timber or other produce which may be removed from a forest annually or periodically - in advance, usually for a short period i.e. generally working plan period, and prescribing the means of achieving the same.

As per American Forest Terminology, Yield from forest is of three kinds viz . (1) Potential yield (2) Regulated yield and (3) Planned yield.

Potential yield: It is the yield which results from the application of the standard treatment (Silvicultural systems).

Regulated yield: The potential yield for a forest or region may show marked fluctuations from one decade to the next which may be unacceptable because of employment and marketing commitments. Therefore, the process of smoothing out these fluctuations is generally known as YIELD REGULATION and the resulting yield is defined as Regulated yield.

Planned yield: The yield which it is finally decided to cut, whether regulated or not.

General principles of yield regulation in India:

(1) Basic aim is the principle of sustained yield.

(2) It aims at the highest possible benefit without the forest being over-exploited.

These two aims are achieved by means of:-

(1) Cutting each crop or tree at maturity and to secure the maximum yield of the required produce.

(2) Cutting about the same amount of material each year or at periodic intervals, and

(3) to limit the area to be cut annually to that which can be regenerated.

In this connection, the celebrated Norway model of yield regulation is worth comparing which is given below:

Bases of yield regulation in Norway.

(a) Cutting at financial maturity (and, implicitly thinning according to a regime that best meets the owner's objectives).

(b) Cutting a Stable quantity, which ensures that yield does not fall at any time, and rises in the more distant future.

(c) Cutting to provide stable income, that is a pattern of yield over time which ensures an income that does not fall

in any year but ultimately rises,

(d) cutting to provide a Stable surplus, that is a pattern of yield which provides certain level of net income, part of which may come from funds saved out of the proceeds of heavier cuts in previous years,

(e) cutting to provide work for a Stable labour force, and

(f) cutting to yield a Constant regeneration area (as in the old central European systems of management by means of a fixed periodic block)

The comparison will reveal that the principle of sustained yield is the basis for any system of regulation of yield all over the world but the latest thinking is not only sustained yield but also maximum possible yield from a forest.

Once again it is to be noted that this yield regulation is only for a shorter period, and the Silvicultural systems adopted to a forest dictates the yield regulation . Secondly when a virgin forest or ill-maitained natural forests are brought under regulation of yield, expected results cannot be achieved in the First Rotation.

Difficulties in I Rotation.

(1) In virgin forets, when taken up for Scientific management,
  (a) overmature, old and feeble trees are required to be removed immediately and quickly, so the yield will be more.

  (b) many of the conditions for natural regeneration are are not favourable.

(2) In ill-maintained forests,

  (a) crop will be irregular both in density and mixture of species.
  (b) valuable species in more accessible areas would have been removed.

(3) No data of growth and composition will not be available

But these difficulties can be overcome by following such systems leading to evenaged crops and equal age gradations or classes can be built up and the desired result will be achieved in subsquent rotations.

The following tabular statement will reveal the impact of system over selection of methods to achieve yield regulation.

System	method of Regulation.
(1) clearfelling, Simple coppice, Coppice with Standard or Coppice with Reserves	By Area
(2) Shelterwood compartment System.	By Area
(3) Irregular shelterwood system	By Volume

Another points to be noted here that Regulation of yield for more than 10 years period will lead to larger fluctuations during actual working.

Regulation of yield may be made not only for final crop but also for Intermediate crop such as thinning etc.

Methods of determining yield.

Determination of yield may be done

(1) By area, (2) by volume and (3) by Volume and Area.

But all these methods are based on

(1) Object of management
(2) Silvicultural System adopted,
(3) Status of growing Stock and
(4) Increment pattern.

In India, only the European methods are followed with some modifications to suit the local conditions.

Regulation of yield is easy incase of regular forests managed with the aim of achieving regular or uniform crops, but is is very difficult in case of irregular forests for the following reasons:-

(1) There is no normal Forests available in Nature.

(ie. All age classes are represented in equal proportions). So Volume cannot be properly predicted in irregular forests.

Maturity is judged by the size of SINGLE STEM and not by average age of a crop. Because in irregular forests, correlation of age and diameter cannot be done, since Stems of same diameter may be of different ages.

(3) Fixing rotation is difficult because all stems will not reach maturity in same rotation period.

(4) It is very difficult to judge whether the regeneration is coming up satisfactorily or not.

A. Yield regulation by Area.

It is easy to apply. It is clear and simple. This was applied in France for Maritime Pine . And it was applied to coppice areas only where their rotation was short. Then it was applied to coppice with standard system with natural or artificial regeneration.

In India, this is applied to clearfelling system in high forests (eg. Tamilnadu and Kerala Teak forests), and to all coppice systems.

Procedure.

(1) Rotation for the crop is fixed.
(2) Area is divided into annual coupes according to the number of rotation years.

(3) If the area is too large, Felling series are constructed and they are divided into annual coupes.

(4) When necessary, Reducing factor (already learnt) is applied for different site qualities to make equiproductive areas.

(5) The formula: Annual = $\frac{A}{r}$ ie. $\frac{\text{AREA}}{\text{ROTATION}}$ E.g. $\frac{1000 \text{ Ha}}{10 \text{ yrs.}}$ = 100 Ha.

Modifications

(1) If the annual areas are uneconomic, the larger areas may be taken up periodically ie. 5 years or [illegible] years period.

Hufnagls variation:

Instead of mere AC= $\frac{A}{r}$, here

$$\text{Annual coupe area} = \frac{\text{Total area}}{\text{Rotation}} \times \frac{\text{Average age}}{r/2}$$

Hufnagls considers that for sustension of the annual yield , the annual coupes obtained by dividing the total area by the rotation should be multiplied by $\frac{\text{Average age}}{r/2}$

The avera-ge age is determined by dividing the sum of products of the average age of each age class and respective area by the total area of the felling series. In irregular forests, we consider only

Eg: The area of felling series is 2976 acres, the rotation is 96 years and the age class distribution as follows:-

							Total area in ac
Age class (years)	1-16	17-32	33-48	49-64	65-80	81-96	
Area (acres)	700	370	330	316	480	780	2976

(1) 700 x 8 = 5600
(2) 370 x 24= 8880
(3) 330 x 40= 13200
(4) 316 x 56 17696
(5) 480 x 72= 34560
(6) 780 x 88= 68640

148575

Note
For each class, the middle age shall be taken.

Average age = $\frac{1,48,576}{2976}$ = 49.9 or 50 years.

Reduced annual area = $\frac{2976}{96} \times \frac{50}{½ x 96} = 31 \times \frac{50}{48}$ = 32 acres.

Regulation by volume

There are various methods are available in this category and they are generally referred as "Formula" methods. The main caution to be taken when these formula methods are used, they shall be followed with modifications and safeguards according to the condtion of forests and reviewing the actual growing stock at this every revision of working Plan.

When volume is taken as main basis these are some secondary basis also shall be considered and on such bases different formula have been formulated as follows:

Main basis	Secondary basis		Name of Formula
Volume	(1) Growing Stock	--	Von Mantel.
	(2) Increment & Growing Stock	--	Austrian
	(3) Size classes and periods	--	French Method of 1883.
	(4) Tree as limit	--	Brandis Method

(1) Von Mantel's formula (Volume based solely on growing stock.)

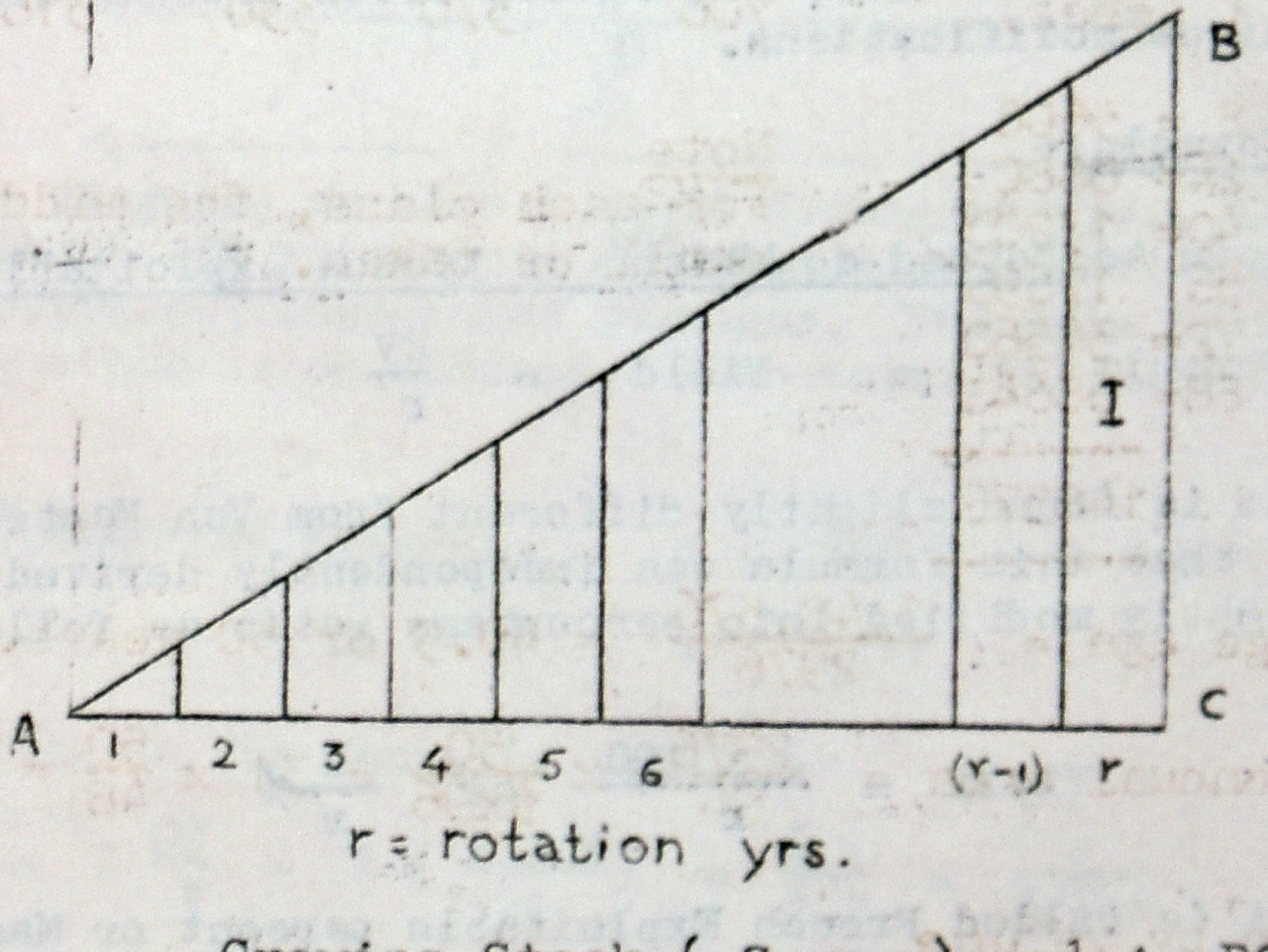
This formula is also known as " Formula of Glorious simplicity" This formula is mainly used for irregular forests than for regular forests.

$$\text{Formula: Annual yield} = \frac{\text{Actual vol. of Growing stock}}{\frac{1}{2}\text{ rotation}}$$

or

$$Y = \frac{V}{\frac{1}{2}r}$$

This can be diagrammatically represented as follows:



$$\text{Growing Stock (Summer)} = \tfrac{1}{2}\, A \times BC$$
$$= \tfrac{1}{2}\, r \times I$$

$$GS = \tfrac{1}{2}\, r \times I$$

$$I = \frac{GS}{\frac{1}{2}r} \quad \text{where } I = \text{Yield}$$

$$Y = \frac{GS}{\frac{1}{2}r} \quad \text{where } GS = \text{volume of while area ABC.}$$

$$Y = \frac{V}{r}$$

Therefore, we can deduce the following:

(1) Yield during the rotation is equal to twice the growing stock.

(2) During rotation, in addition to growing stock half the increment is felled and the other half goes to form the new growing stock for next rotation.

(3) In this, we shall always assume that the increment is normal even though in practice, it does not.

Merits:-

(1) It is easy to apply since it merely requires the actual growing stock and rotation.

(2) It regulates the yield according to the actual growing stock by which over-stocked forests will be heavily felled and under-stocked forests lightly felled.

(3) It is useful as a preliminary step in yield regulation, especially in irregular forests.

Demerits:-

(1) It is inelastic because the surplus or deficit present in growing stock is spread over half the rotation and avoids frequent enumerations and re-calculations.

(2) It involves a complete enumeration of growing stock which is impracticable.

(3) Since it neglects the age class distribution and the rate of growth of stands, regulation often becomes faulty and requires modifications.

2. Masson's formula:-

It is known as Method de Masson or French exploitable percent.

$$\text{Formula} = \text{Yield} = \frac{2V}{r}$$

Though it is found slightly different from Von Mantel's formula, French claims that this formula was independently derived by Masson. Now it is slightly modified into percentage ratio as follows: If V is 100, then

$$\text{Yield} = \frac{2 \times 100}{r} \quad \text{or} \quad \frac{2}{r}\%$$

And so it is called French Exploitable percent or Masson's ratio.

3. Modifications of Von Mantel's formula:

In both Von Mantel's and Masson's formula to find out actual growing stock, enumeration has to be done upto 0 cm. girth which is impracticable. So, some modifications have been made on Von Mantel's formula which are discussed below:

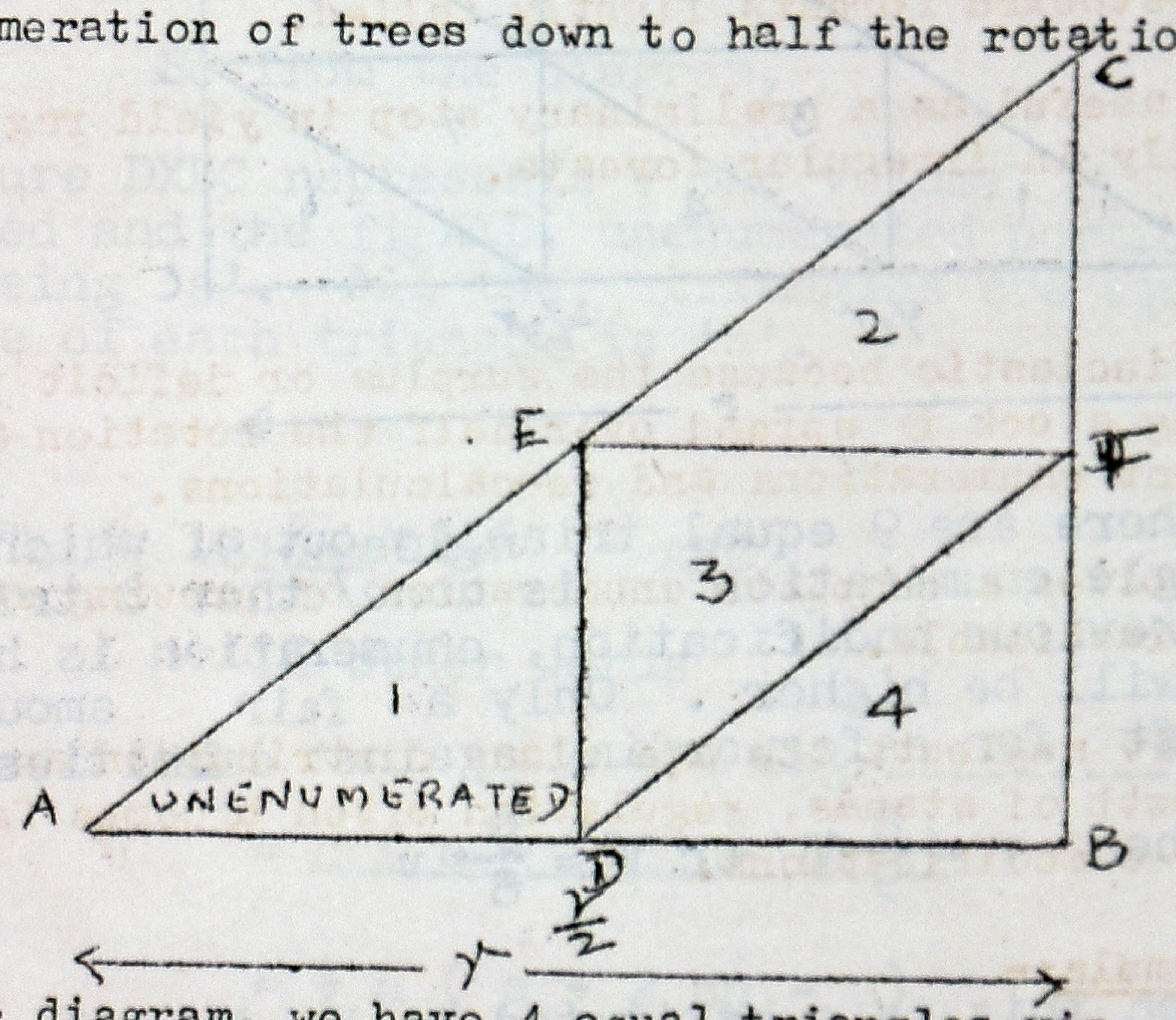
(a) Howard's modification:

In this formula,

(1) Assumption is that the girth is directly proportional to the age and to suit the yield regulation in selection forests, enumerations are carried down to half the Exploitable girth.

So, the datas required in this case are

(a) rotation corresponding to exploitable girth.
(b) determination of the girth corresponding to half the rotation age, and
(c) enumeration of trees down to half the rotation age.



From the diagram, we have 4 equal triangles viz., ADC, DFB, DEF and ECF, in which ADE represents ~~na~~ unenumerated position and the other 3 triangles represent enumerated portions. The only 3/4th of the total growing stock is considered. When total Volume is V, enumerated Vol. is v.

Then v (enumrated volume) = 3/4 V

or V = 4/3v

so, substituting in Von Mantel's formula,

$$Y = 2\frac{GS}{r} = 2\left(\frac{v \times 4}{3r}\right) = \frac{8v}{3r} = \frac{v}{3/8\text{-}r}$$

By Howard's modification, the modified formula is

$$Y = \frac{v}{3/8\ r}$$

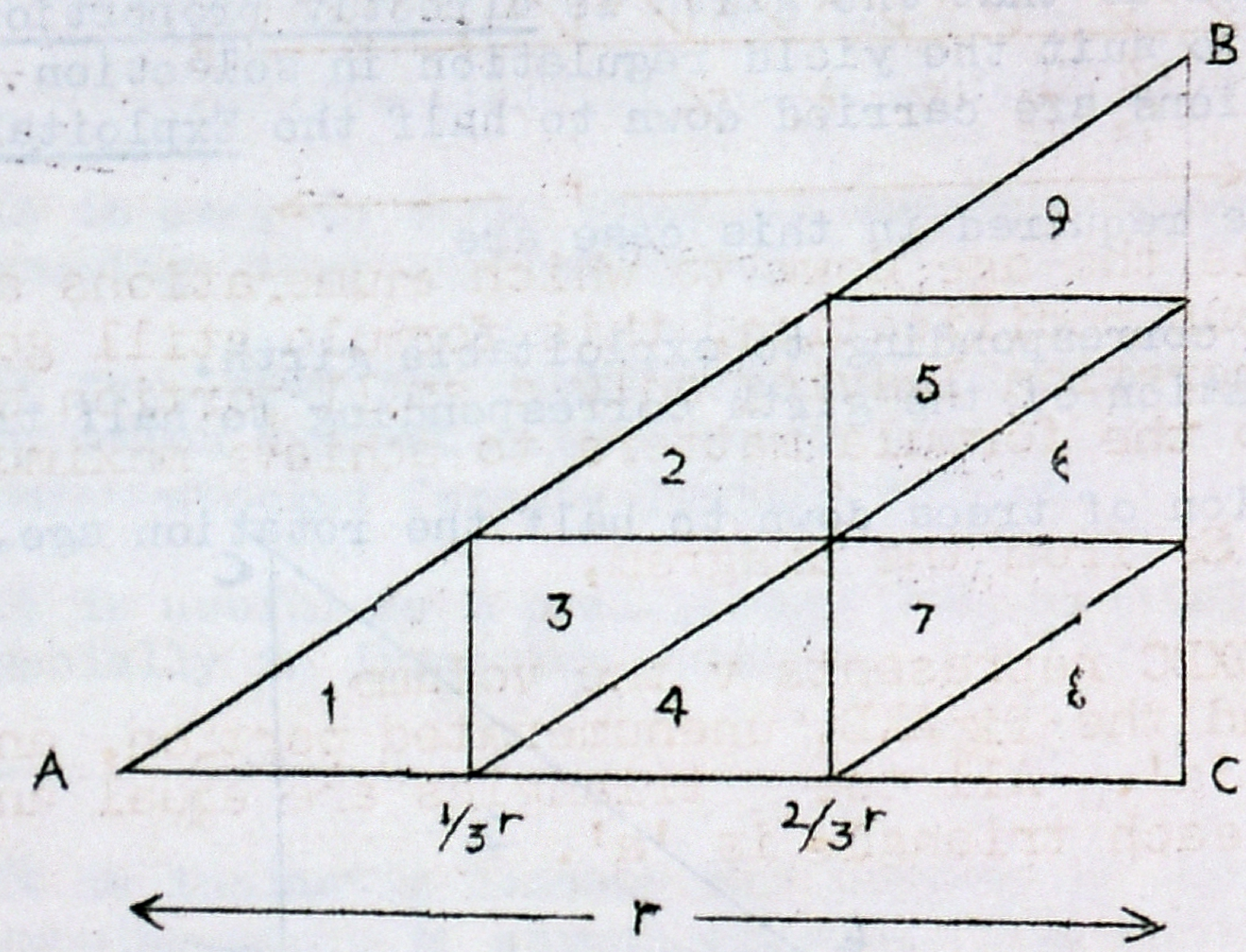
$V_e = \frac{3}{4} V_r$

$V_r = \frac{4}{3} V_e$

By this modification, yield to be obtained is found to be lesser than we obtained from Von Mantel's formula which helps keep a good amount of yield as substitute and safeguard against natural clamities.

(b) Burma modification

In this, enumeration is done to the diameter corresponding tc 1/3 rotation, x This is still further improvement Howard's modification.



Here there are 9 equal triangles out of which excepts first triangle enumeration is done/other 8 triangles, /in unlike previous modification, enumeration is higher and yield also will be higher . Only a fair amounts of yield is left for safeguarding against calamities.

$$\text{Then} \quad v = \frac{8}{9}V \quad \text{or} \quad V = \frac{9}{8} v$$

When this is substituted in Von Mantel's formula,

$$Y = \frac{2GS}{r} = \frac{2}{8} \times \frac{9v}{4} = \frac{9}{4}\frac{v}{r} = \frac{v}{4/9\ r}$$

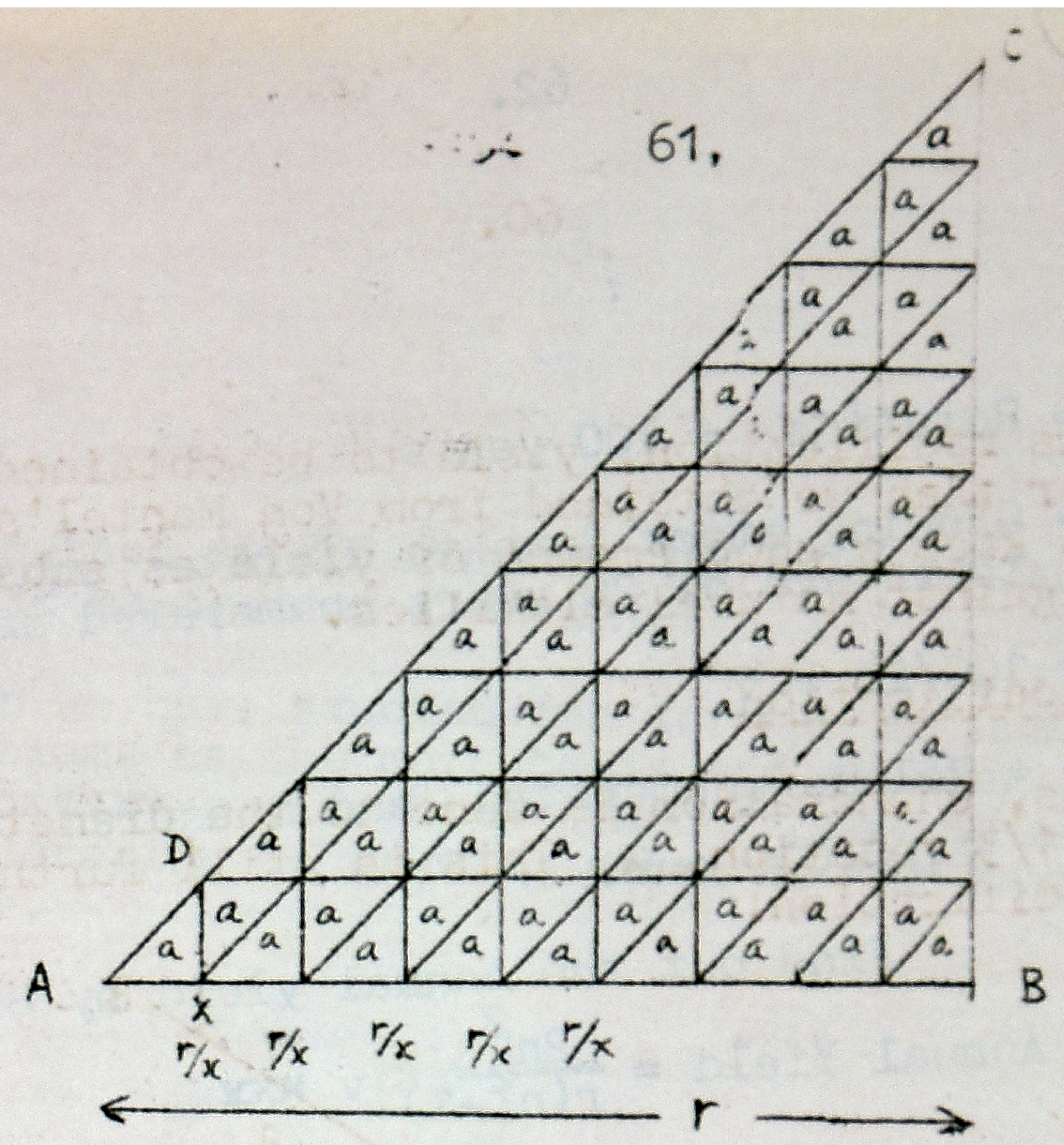
(c) Simmons and Blanford's Formula

$$Y = \frac{2n^2}{r(n^2 - 1)} \times v$$

where Y is yield

$$n = \frac{r}{x} \quad \text{ie.} \frac{\text{rotation}}{\text{Age of old age class in enumerated portion.}}$$

v = Volume of enumerated portion.



Here x is the age down to which enumerations are made. Unlike previous modification, this formula still goes nearer to complete enumeration leaving only a small portion unenumerated. The desire to the formula matters to achieve maximum yield.

So from the diagram,

Figure DXBC represents v the volume enumerated and the fig AXD, unenumerated portion, and its volume being 'a'. All the triangles are equal and so volume of each triangle is 'a'.

Then

V (Total Volume) = ABC

In other words

$= a + 3a + 5a \text{ ---------} (2n - 1)a$

$= \frac{n(a + (2n - 1)a)}{2}$

$= \frac{1}{2} n (a + 2an - a)$

$= \frac{1}{2} \times 2an^2 = an^2$

Enumerated volume is = V - a

or

Fig DxBC = ABC - Fig AxD

When $V = an^2$,

$v = an^2 - a = a(n^2 - 1)$

Therefore $V : v :: n^2 a : (n^2 - 1)a$ (remove a)

$V : v :: n^2 : (n^2 - 1)$

Then $V = \left(\frac{n^2}{n^2 - 1} \right) v$

Annual yield $= \frac{2V}{r}$ substitute the value of V now obtained,

Then $Y = \frac{2}{r} \times \frac{n^2}{n^2 - 1} \times v$

or $= \frac{2n^2}{r(n^2 - 1)}$

Eg. r = Rotation = 100 years

n = Growing stock down to diameter equivalent to an age of 20 years enumerated and measured.

= 100/20 = 5

V = Volume enumerated and measured 2,00,000 cum.

∴ Find out the Annual yield by Simmon's Formula?

$$\text{Annual Yield} = \frac{2n^2}{r(n^2-1)}\ v$$ ~~xxx~~

$$= \frac{2 \times 5^2}{100\ (5^2-1)} \times 2{,}00{,}000$$

$$= \frac{50}{100 \times 24} \times 2{,}00{,}000 = \frac{2{,}00{,}000}{48}$$

= <u>4,4166 cum.</u>

(d) <u>Smythies' modification.</u>

Smythies has taken an arbitrary age below which the produce is not useful. And that age is given in terms of Girth or diameter. ie. x years

Please see Figure in page No. 11

Triangle ABC represents normal Growing Stock Enumeration is done down to a girth or diameter equivalent to an age "x" years.

In the triangle,

xD is drawn parallel to AC

Figure x EBD is drawn and represents the yield in (r -x) years.

Triangle X BD represents enumerated portion and Triangle x ED represents non-enumerated part.

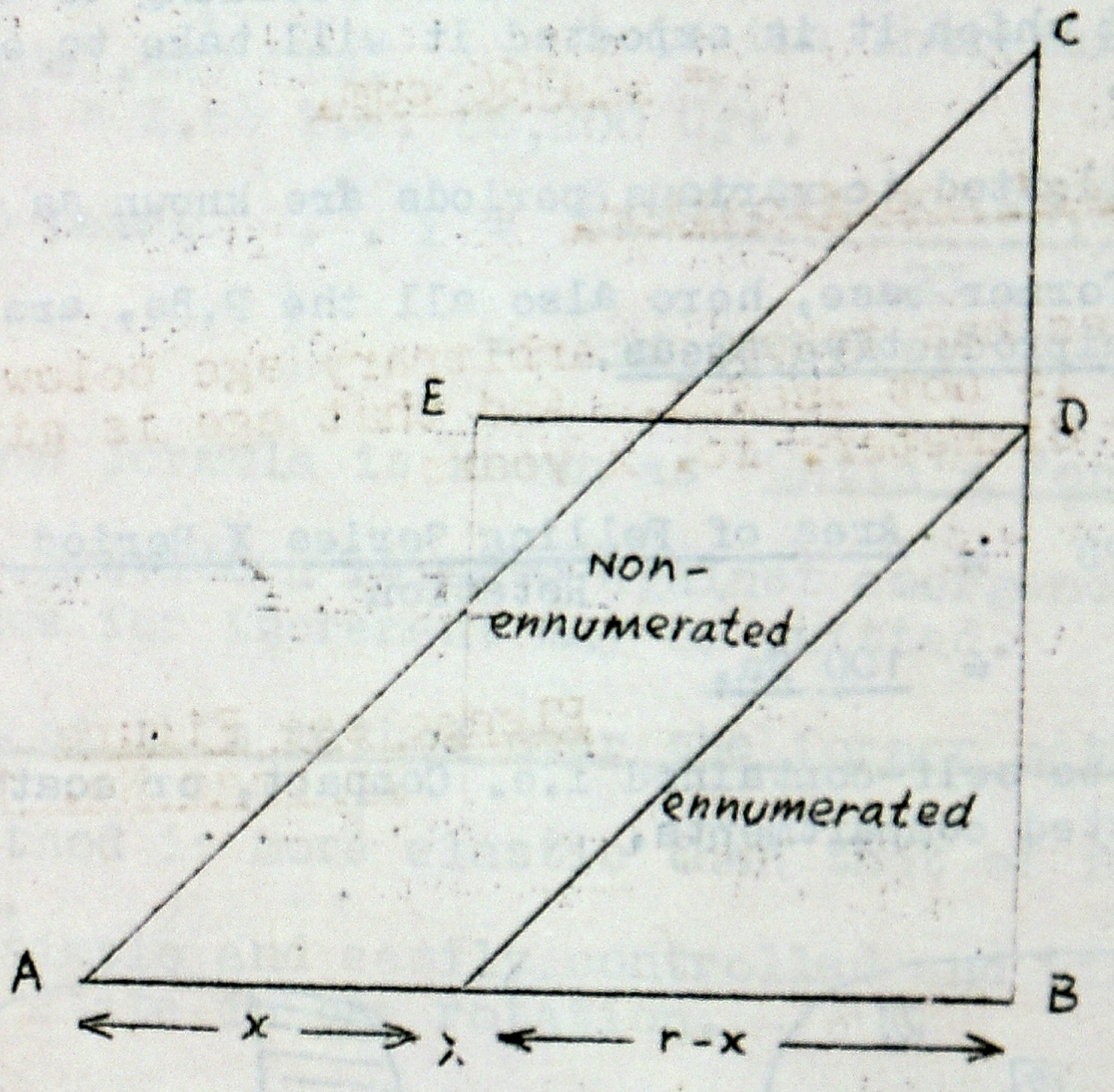
Enumerated volume is 'v' = x BD

yield in (r -x) years = Ex BD
= 2 XBD
= 2 v

Then Annual yield $= \frac{2v}{(r-x)}$

This method is followed in the case of Dandeli natural Teak management (Karnataka)

So far we have studied the formula methods based on volume as the main basis and growing stock as the secondary basis which aimed at coming nearer to the enumeration of growing stock to the maximum practicable.



Note: The drawings by Shri Y.K.Sahu (1982-84).

So far we studied the formula methods of regulation of yield taking " Volume" as the main basis. Now we will study few other methods of yield regulation, mainly, of irregular forests.

(1) Based on area
(2) Based on area and allotment

The former case has already been dealt with. The division is based either on equal annual area or equiproductive annual area or with Hufnagl's variation vide page 55 & 56

The second case is discussed as below:-

(1) The felling areas are not permanently fixed as done in the former method.

(2) The compartment and sub-compartments of the working circles are allotted to various periods of rotation.

(3) The rotation of the species is divided into number of periods.

(4) The length of the period is decided according to the length of time during which it is expected it will take to establish regeneration.

(5) The area allotted to various periods are known as " Periodic Block".

(6) As in the former case, here also all the P.Bs. are either equal area or equiproductive areas.

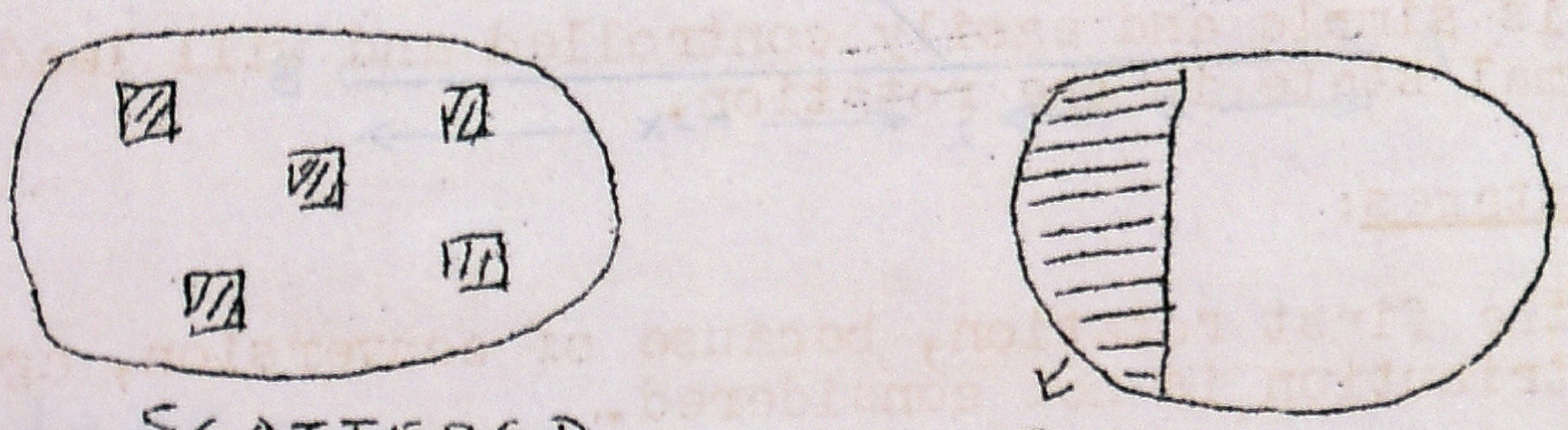
For e.g.

$$\text{Area of PB} = \frac{\text{Area of Felling Series X Period}}{\text{Rotation}} = \frac{400 \times 20}{80}$$

(100 handwritten above the crossed-out figures)

= 100 Ha.

(7) A P.B. may be self-contained i.e. Compact, or scattered and made up of selected compartments.



SCATTERED   COMPACT

(8) All the compartments selected for P.B. shall be inspected, described, their reduced areas are determined (according to density and quality) and on the basis of their

condition and degree of maturity provisionally allotted to various P.Bs.

(9) Annual yield is determined only for the regeneration block i.e. P.B.I (in India).

(a) Standing volumes of merchantable trees in P.B.I is determined either by measurement or from Yield Tables and the increment for the half period is added.

(b) The total of the above is then divided by the number of years in the period gives the average annual yield during the first period.

Hence, the formula is as follows:-

$$Y = \frac{V + \frac{Pi}{2}}{P}$$

Where Y is the Yield
V is the volume of Merchantable trees.
P is the period of regeneration.
i is the increment.

Eg. V = 5,387,487 Cft.
i = CAI = 1.6% i.e. 86,200 Cft.
P = 30 years

$$\therefore Y = \frac{5,387,487 + (86,200 \times 15)}{30} = 222,600 \text{ Cft.}$$

The above formula is known as "Cotta's Formula".

(10) To provide a reserve against emergencies, sometimes, allowance for increment may be omitted.

Advantages of this method over the former method (Based on Area)

(1) The method is more elastic than that of fixed annual coupes.
(2) It is simple and easily controlled and will lead to normal state in one rotation.

Disadvantages:

(1) In the first rotation, because of conversion, age class distribution is not considered.

(2) As insurance against adverse climatic influences, surplus growing stock is not removed or reduced but carried over the whole rotation.

(3) Yield may be uneven during the first rotation.

As stated in the beginning (Point No.9), only one Periodic Block is fixed and there is no early fixation of other Period Blocks, the method is known as "Single Periodic Block" method.

Floating Periodic Block:

(1) This is an improvement over "Single Periodic Block" method.

(2) Neither the size of P.B. nor the length of "Period" is pre-determined. All woods which are overmature, mature or nearly mature, which are ready for regeneration or in which regeneration has already appeared, may be included in F.P.B.

(3) In an evenaged forests which is normal or nearly normal, the extent of woods requiring inclusion will have correct proportion but, in an abnormal forests, the presence of large extent of OVERMATURE woods and the presence of advance growth over a large area may be common. So in such case, F.P.B. Area is limited to convenience.

(4) This Floating F.P.B. method was evolved in France under the name of " Quartier Bleu" method i.e. in the map, regeneration area will be coloured "blue" and rest of the areas are uncoloured and called "Quartier blanc". In this method, Duchaufour's formula is followed.

(5) Important feature in this method is that in each revision of Working Plan (a) Compartments are allotted for "Quartier bleu" as follows:-

Group I: Compartments already under regeneration.
Group II: Compartments which should come under regeneration during the W.P.Period.

(b) The volume of Timber in each compartment in Floating P.B. is determined.

(c) The annual yield is determined by dividing the volume by the length of time in which it is expected each compartment will be regenerated.

From the above, it is understood that (i) annual yield is calculated for each compartment of Floating P.B. and not for whole Floating P.B., and (ii) the yield is regulated for each working Plan Period.

(6) In Germany, Floating Periodic Block is determined under " Judeich's Method of "Stand Selection Method".

(a) The rotation and Working Plan Period are first decided. Only short Working Plan Period is employed (10 yrs.).

(b) The forest is divided into convenient sized compartments.

(c) The compartments are inspec-ted and described with particular reference to the treatment they require.

(d) Then the suitable compartments are selected for felling and regeneration during Working Plan Period.

(e) The determination of annual area:

(i) The total area of felling is divided by rotation.
(ii) From this, the areas to be felled during the Working Plan Period is calculated.

For e.g. Total area = 10000 Ha., Rotation = 80 yrs.
W.P. Period = 10 yrs.
Mean Annual Coupe = $\frac{10000}{80}$ = 125 Ha.

∴ Area for W.P. Period = 125 x 10 = 1250 Ha.

(iii) If the total area of compartments selected (as per (d) is within 10% of the mean periodic coupe calculated as per Pt.e(ii), no further adjustment is necessary. If it is larger, some compartments may be omitted and if it is smaller, some more compartments, even though not quite mature, will be included.

B. Yield regulation in irregular forests:

(1) Based on Volume and Increment

HEYER'S formula or AUSTRIAN method.

Annual Yield = actual annual increment (CAI) + $\frac{\text{Actual GS} \pm \text{Normal G.S}}{\text{years over which the surplus or deficit is distributed.}}$

$$y = Ir + \frac{Ga - Gn}{x}$$

For this, (1) normal G.S. is obtained from yield tables or by using the formula, G.S. = I x $\frac{r}{2}$

(2) Actual G.S. is obtained by enumeration.

(3) Increment is the sum of actual Final mean annual Increment.

(4) 'x' is fixed with reference to local exigencies.

Overmature timber means (quick) less number of years.

HUBER'S modification:

Huber substituted "MAI" in place of "CAI" in the formula:

This method is adopted for both regular and irregular, extensive forests. Since this ignores area and age, it is called "office method" than a "field method".

(2) Hufnagl's method:

Refer V.P.Mathur's Book on "Forest Management".

(3) French method of 1883 and its modification:

Under this, yield regulation by volume is based on size classes and growing stock. It was originally devised for regulating the yield of SELECTION forests, and also applied to the forests worked under Irregular shelterwood system. The procedure is as follows:

(1) Based on the objects of management, the forest is inspected and the EXPLOITABLE diameter is determined.

(2) Through Stem analysis and adding a few years for establishment of regeneration, ROTATION corresponding to the detemined EXPLOITABLE DIAMETER is arrived at.

(3) The Growing Stock is then divided into following 3 classes:

(a) Old class with trees corresponding in diameter from 2/3 of Exploitable diameter to the full exploitation diameter.

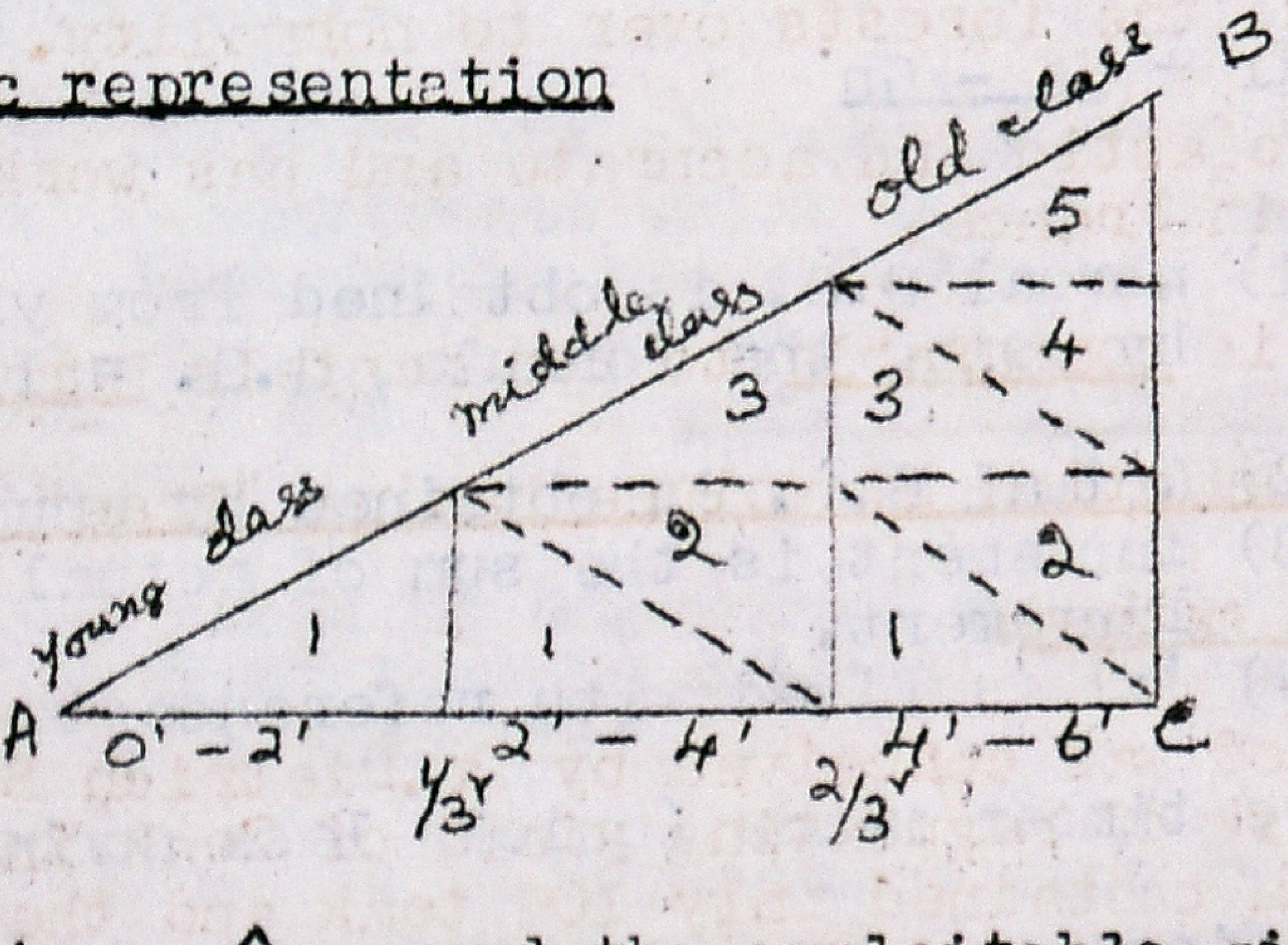
(b) Middle class with trees ranging in diameter from 1/3 to 2/3 of exploitable diameter,

and(c) young class consisting of trees less than 1/3 of exploitable diameter.

(4) All old and middle classes Growing Stock is enumerated i.e. upto 1/3 rotation age.

(5) The ratio between the volume of old class and middle class is 5:3, it is considered as normal.

Diagramatic representation



If ABC is a $\triangle$, and the exploitable girth is 6', old, middle and young classes are represented having the ratio of 5:3:1 respectively by means of drawing perpendicular from the point corresponding to 1/3r and 2/3r.

Then the formula is that as follows:

$$\text{Final Yield} = \frac{\text{Volume of Old class}}{\text{1/3rd rotation}} + \frac{\text{Vol. of old class + Increment per unit vol. per annum of old class}}{2}$$

$$\text{i.e. } Y = \frac{V_o}{r/3} + \frac{V_o \times t}{2}$$

(6) In Selection forests, intermediate yield will also be available due to silvicultural operations and so it is also added to the Final yield, and the total yield is arrived at as follows:

Intermediate yield for middle class by means of silvicultural operation such as things as follow:

$$I.Y = \frac{1}{n} (V_m \times t_2)$$

Where, Vm = Volume of middle class

t_2 = Increment per unit p.a. of middle class.

n = a factor varying according to circumstances.

So,

$$\text{Total Annual Yield} = \left(\frac{V_o}{r/3} + \frac{V_o \times t_1}{2} \right) + \frac{1}{n} (Vm \times t_2)$$

normally, the figures for $t_1 = 0.01$, $t_2 = 0.03$ and $n = 3$.

(7) Adopting of this method is said to have the following advantages:

(i) The yield is in accordance with the condition of the forests.

(ii) It leads the forests over to normality.

(iii) It is elastic and accurate and has worked well in practice in France.

NOTE: This is comparable to Von mantels Burma modification.

(c) Yield Regulation by volume basing "Tree" as Unit.

(a) Brandis' method:

This method was conceived by Dr.Dietrich Branch when he faced the task of regulating yield of Teak in Burma Forests in 1856 which contained only 10% teak and the demand for teak was great and its exploitable size was 6' at that time. The procedure adopted by him was as follows:

(1) Adopting 18" girth classes and keeping the minimum girth for enumeration as 18", complete enumeration was done.

(2) Through Stem analysis,

i) the current rate of girth inc-rement and
ii) the period of transition from each class to the next above,

were ascertained.

(3) The transition periods were then added up and allowing a few extra years for safety, the rotation corresponding to the exploitable size was determined.

(4) Survival percentages based on extensive observations in the forests (Test Plots) for each class were also determined.

(5) The total number of actual trees in each girth class is then multiplied by the Survival percentage for that class and the potential number of trees for harvest were arrived at.

(6) A felling cycle was also fixed which was a sub-multiple of rotation fixed and was not less than the period of transition for II class trees to pass on to I class.

(7) Then the formula for yield was as follows:

A.Y = (Av. No. of trees reaching Exploitable size every year) + a fraction of surplus number of trees above exploitable size (if any)

(8) The fraction of Surplus number of trees may be fixed according to circumstances.

(i) It may be the whole i.e. all the Surplus may be harvested in the first felling cycle.

or

(ii) A reserve; equivalent of the number of trees that pass into Class I in half the felling cycle.

Eg.: (1) Exploitable girth = 6' or 72"

(2) Result of Enumeration: (over 18" girth) in 18" girth class

I over 7'6" girth	=	31,523 trees
II 6' to 7'6"	=	18,114
III 4'6" to 6'	=	42,768
IV 3' to 4'6"	=	1,01,737
V 1'6" to 3'0"	=	1,50,910
		3,45,052 trees

(3) Rate of growth or the transition period required to pass onto next class from Stem analysis.

Girth	Age in years	Years required to pass on to next class
1'6"	31	
		29 years
3'0"	60	
4'6"	93	
		33 years
6'0"	130	
		37 years
7'6"	156	
		26 years
	Total	125 years

(4) Rotation = 125 years + 35 years to reach 1'6" girth (with safety allowance)

= 160 years.

(5) Felling Cycle = 32 years i.e. { Submultiple of rotation (1/5); not less than the period of transition for II class to I class (26 years) }

(6) Survival per cent obtained from test plots:

Class I	= Over 7'6"	-- 95%
II	- 6' to 7'6"	-- 85%
III	- 4'6" to 6'	-- 70%
IV	- 3' to 4'6"	-- 50%
V	- 1'6" to 3'	-- 25%

(7) Applying the percent to item 2, we get potential trees.

Class I	- 95%	of 31,523	-- 29,947
Class II	- 85%	of 18,114	-- 15,397
Class III	- 70%	of 42,768	-- 29,938
Class IV	- 50%	of 1,01,737	-- 50,869
Class V	- 25%	of 1,50,910	-- 37,728

(8) From the above table, total number of trees from Class II to Class V : 1,33,932 trees.

Total period of transition : 125 years.

∴ Average number of trees that pass on to next above : $\frac{1,33,932}{125}$ = 1071 trees. - (1)

(9) Surplus trees i.e. Class I - 29.947 from this, Average to equivalent number of trees that pass onto I class in half the felling cycle.

$$= \frac{29947 - (16 \times 1071)}{32(f.c.)} \rightarrow (\tfrac{1}{2}\ f.c.)$$

= 400 trees - (2)

(10) So, the total permissible yield = 1071 + 400 = 1471 trees, annually.

Note: Even after arriving that figure of annual yield, some allowance may be deducted for the following reasons:

(i) To preserve some mature trees for regeneration (Mother trees)

(ii) In view of Price Increment in trees more than 8 & 9 ft. in girth.

So, from the example, about 71 trees may be reserved for the above purposes to only 1000 trees may be permitted to be removed.

This method was adopted in India in South Chanda and North Chanda Forest Working Plans for teak and other timber species and Semul trees respectively.

(b) Hufnagl's method (Austrian Forester- 1893)

This was devised for remote Selection Forests. The following formula was adopted.

$$\text{Annual yield} = \frac{n_4}{a_4-a_3} V_4 + \frac{n_3-n_4}{a_4-a_3} V_3 + \frac{n_2-n_3}{a_3-a_2} V_2 + \frac{n_1-n_2}{a_1-a_2} V_1$$

While a_1, a_2, a_3, a_4 - Mean age or Average age of each class

n_1, n_2, n_3, n_4 - Number of trees in each class

V_1, V_2, V_3, V_4 - Average Volume per tree in each class.

Procedure

(1) Enumeration of trees in 4 age classes.

(2) Calculation of Average volume per tree in each class

i.e. $\dfrac{\text{Total No. of volume of trees in each class}}{\text{Total No. of trees enumerated in each class}}$

(3) Period of exploitation equals approximately $a_4 - a_3$ i.e. Class I - Class II.

(4) Length of time required is obtained by deducting the mean age of lowest class from the mean age of next higher class unlike in Brandis method wherein, it is determined by Stem analysis method.

(Eg) 10 years age class 11-20, 21-30, 31-40, 41-50

$a_1 = 15$, $a_2 = 25$, $a_3 = 35$, $a_4 = 45$

$n_1 = 500$, $n_2 = 280$, $n_3 = 200$, $n_4 = 180$

$V_1 = 2$cum, $V_2 = 5$ cum, $V_3 = 12$ cum $V_4 = 16$ cum.

$$\text{Then Yield} = \left(\frac{180}{45-35} \times 16\right) + \left(\frac{200-180}{45-35}\right) 12 + \frac{280-200}{35-25} 5 + \frac{500-280}{25-15} 2$$

$$= \frac{180 \times 16}{10} + \frac{20}{10} \times 12 + \frac{80}{10} \times 5 + \frac{220}{10} \times 2$$

$$= 288 + 24 + 40 + 44 = \underline{396 \text{ cum.}}$$

(c) SMYTHIE'S Safeguarding formula or Yield regulation by Percentage of trees.

This is applied mainly to Sal areas of U.P. and M.P., managed under Selection felling. Also adopted by few Working Plan officers for the forests exploited under "Selection System" e.g. Shri John Joseph's Working Plan of Coimbatore North Division.

This formula was based on the following three assumptions:-

1) The object of management is to ensure as far a s possible a sustained or increasing yield of exploitable trees above the exploitable limit at every felling cycle.

(2) The exploitable trees are already available and being recruited anywhere (scattered in various compartments and that the fellings pass regularly in consecutive annual coupes in a felling cycle of 10,15,20 or 30 years as the case may be.

(3) The middle age and younger diameter classes are well-represented and that the present rate of recruitment in the two highest diameter classes will not decrease for many decades.

Procedure

(1) The W.P.O. enumerates the forests and ascertains the present Stock of I and II class tree per acre and they are symbolised by symbols I and II.

(2) He also enumerates III and IV classes to justify that younger diameter classes are well represented.

(3) Then with the following formula, the number of II class trees per acre that pass up into II class during the felling cycle, is calculated:-

$$x = \frac{f}{t} (II - Z\ \%\ of\ II) \quad ----(1)$$

Where,

f = felling cycle,
t = time taken for a II class tree to pass up into I class.
Z = % of II class trees that die or do not pass up in 't' years i.e. mortality percentage.

(4) Annual yield can be prescribed by two methods as follows:

Method 1:

$$Yield = x \frac{(Total\ area\ of\ felling\ series)}{felling\ cycle}$$

Method 2:

$$Y = \left(\frac{x}{I + \frac{x}{2}}\right) \times 100$$

Where, I = Number of I class trees at present.

x = Number of trees which pass on to I class during felling cycle.

Eg. from Balaghat Forest Division of M.P. for Sal Area Datas

(1) Exploitable diameter -- 20" at BH.

(2) Time taken to reach 20" at BH = 170 years.

(3) Felling cycle fixed (f) = 25 years (which is equivalent to half the period of 50 years for a (t) 16" dia. tree to reach 20").

(3) Tree classification:

20" and over = Selection trees
20" - 24" dia. = Mature
~~24" and over = Overmature~~
16" to 20" = Pre-selection class

(4) Z% i.e. mortality per cent = 33 1/3% i.e. trees disappearing in 't' years.

(5) Enumerated II class trees = 16,677
I class trees = 7,804

$$\text{So, } x = \frac{f}{t} (\text{II} - 33\tfrac{1}{3}\% \text{ of II})$$

$$= \frac{25}{50} (16{,}677 - 5559) = 1/2 \times 11{,}118 = 5559 \text{ trees.}$$

$$\therefore y = \frac{x}{(I + x/2)} \times 100 = \left(\frac{5559}{7804 + \frac{5559}{2}} \right) 100$$

$$= \frac{555900}{10583} = 52\%$$

Therefore only 52% of trees in the Selection class will be harvested. In other-words for every tree marked, one tree will be retained.

Comments on this formula:

(1) No corelation to the increment of the forest as a whole.
(2) Requires much data from enumeration and more statistical data for estimating 't' and 'Z' than volume yield formula and is, therefore, susceptible to go wrong.
(3) It can be called as the modification of Brandis method since the regulation of the yield is based entirely on the stocking of II class trees.
(4) Exploitable diameter is arbitrarily fixed in this method.

Note: Regarding the application of Smythies' Safeguarding formula, please see your tour journal for Hassanur camp.

GB

CHAPTER - VIII

YIELD REGULATION APPLIED TO INDIAN FORESTS

As already knew very well that India is a vast sub-continent enjoying varying climate and soil conditions which in turn gives rise to various types of forests vegetation. There, therefore, cannot be a single method of treatment for all such different types of forests and various silvicultural systems are being adopted to suit the specific needs of each type. Yield regulation is mainly based upon the silvicultural system and on various methods of yield regulation are employed in India. The study of working plans of various forest divisions of our country will reveal those different methods of yield regulation.

Basically all the silvicultural systems and in turn, the methods of yield regulation which are being applied in India, are the modified versions of European systems and methods only. In the preceding chapter we studied that methods of regulations and now we will see which are the methods used where in India.

For the purpose of yield regulation, the timber only are considered and such major timber species in India are Silver fir, Spruce, Deodar, Pine spp., Evergreen spp., Sal, Semul, and Teak and its associates such as Rosewood, Terminalias, Venteak, Pterocarpus spp., etc., So we will now see under which methods of yield regulation each such species are harvested.

I. Silver fir and Spruce: They are found in Himalayan region comprising of Jammu & Kashmir, Himachal Pradesh, Uttar pradesh and West Bengal. Method adopted: Yield regulation is by number of trees calculated by Brandis method i.e. taking tree as unit.

II. Deodar Forests: These are available in Jammu & Kashmir , M.P. and U.P. Selection system is adopted and yield is regulated following Smythie's Safeguarding Formula.

III. Pine Forests: Pine species are available in Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh, West Bengal, Assam, Manipur states. With enumeration done down to 20 cm. diameter, Smythie's safeguarding formula is being employed.

IV. Evergreen species including Rosewood, etc.: These forests are available in Assam, Andamans, Karnataka, Kerala, Maharashtra, Tamilnadu. Except in Kerala and Tamilnadu, the yield is regulated by volume with an area check and an exploitable girth limit.

In Kerala and Tamilnadu, Selection system is adopted with yield regulation by Smythie's Safeguarding Formula.

V. Moist deciduous forests: In Northern Moist Deciduous forests, Sal is the main species occurring in U.P., M.P., Bihar and Assam. Each state follows a different method of yield regulation as given below:

U.P. Sal Forests	:	Smythie's Safeguarding formula
M.P. Sal Forests	:	Brandis method (Tree as unit)
Bihar Sal Forests	:	By Area
Assam Sal Forests	:	By Volume

In Southern Moist Deciduous Forests which is dominated by Teak (in M.P., Tamilnadu, Kerala).

M.P., & Tamilnadu : Yield regulation by Area

Kerala : Yield regulation by Volume and Area.

It is noteworthy that Kerala has got the distinction of being the first state where its Teak forests are being worked under Financial Rotation based on " Money Yield Tables" in the whole of India.

For detailed understanding various working plans may be perused.

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CHAPTER - IX

MULTIPLE USE OF FORESTRY

Forests are many faceted asset to the man-kind. In the preceding Chapters, we dealt with the economic aspect of forests. As I mentioned in the first two Chapters, the utility of forests and object of managements are varied. It was highlighted at the Vth World Forestry Congress held in America in 1960 which flashed the theme " Multiple use of forestry " for the Congress. It emphasised " the management of forests in a manner that will conserve the basic land resources while yielding a high level production in the Five major uses, namely wood, water, forage, recreation and wildlife, for the benefit of greatest number of people in the longrun."

Therefore, apart from the management of wood, forest managers are expected to fulfil the other 4 needs of man-kind which are identified as follows:-

(1) Management of Catchment areas (Watershed Management)
(2) Management of forests for grazing (Forage)
(3) Wildlife Management
(4) Recreational uses of Forestry

(1) Management of catchment areas:- One of the protective functions of forests is " Water Conservation". Water requirements of man-kind are met with by two main sources viz. Rainfall and sub-soil moisture available through springs and tapped through wells. Agriculture depends upon three sources of irrigation namely River Irrigation, Well irrigation and Rainfed irrigation. To keep all these sources in proper condition, forest plays a prominent role. Mountains are the birthplaces of many a river. Most of the major rivers in India have their origin in mountains only. When these mountains are kept under proper tree cover, they act as the catchment areas for perennial rivers. Not only that, soil erosion due to snowfall, rainfall, etc., also is minimised due to the tree cover in such catchment areas. We, in India, are able to understand the real role of forests in such areas only after inflicted with the problems of landslides, flash floods, heavy soil erosion, silting up of lakes and reservoirs, etc. after the devastation of forest in such areas. The forests are natural reservoirs since they absorb rainfall reducing the surface run-off to the minimum. The conserved rain water is then released when it is needed in the form of springs and perennial streams.

Though it is a debatable point that whether forests attract rains, it is accepted that they affect the distribution of rainfall over a period of time especially near equatorial regions. It is also accepted that forests influence micro-climatic conditions in the forested regions.

Apart from acting as natural reservoirs, forest in catchment areas, minimise the soil erosion because forest canopy prevents raindrop erosion. Forest vegetation by breaking the velocity of the raindrops, by forcing rain water to get absorbed in the soil, by causing physical obstruction against running water and finally by holding the soil by roots, helps in conservation of soil.

The absence of such forest cover in catchment areas result in siltation of river beds, overflowing of banks by river water during rains, faster silting up of dams reducing their life.

For these compelling reasons, an effective management programme is necessary in catchment areas.

Our National Forest Policy of 1952 rightly emphasised " an immediate and speedy programme for the Reconditioning of the mountainous region, river valleys and coastal lands by establishing protective forests over larger areas, preserving the existing ones. The primary object of management of such forests should be to utilise in full their protective influence on the soil, the water regime and the physical and climatic factors of the locality". It went a step further and prescribed that " as an insurance against denudation, a much larger percentage of the land, about 60% should be kept under forests for protective functions in the Himalayas, the Deccan and other mountainous tracts liable to erosion".

National commission on Agriculture (1976) in its report reiterated the role of forests in catchment areas and said: "The importance of the forests in modifying the hydrology of watersheds and in soil conservation has been well recognised. The forest whatever its magnitude, is expressed by the manner in which the forest receives, stores and releases potential flood-producing rainfall. The hydrologic processes that govern disposition of precipitation, and hence affects erosion of soil are (a) interception by the canopy or other tree parts, (b) reduction of velocity of surface flow due to forest litter, de-composed organic matter, mass of roots, etc., thus increasing infiltration and percolation and (c) moderation of peak flows".

Forest land occupies a large proportion of the river valley catchments and exercise material influence upon soil stabilisation and stream flow characteristics of the watersheds and so, the condition management and improvement of forest lands should form part of watershed management programme. Many catchment areas in India do not have enough percentage of forest cover and it has been suggested that "particular attention should be paid to the degraded forest lands which should be brought back to proper condition through reforestation wherever necessary".

So, the management of catchment areas require following treatments:-

(1) The existing forest cover shall be well protected.

(2) The degraded forests cover shall be brought back to proper condition through reforestation.

(3) The soil conservation measures shall be adopted to minimise soil erosion in those areas wherever necessary.

(4) Grazing shall be prohibited completely.

(5) Shifting cultivation by the tribals in these areas shall be discouraged by providing them alternate home-stead lands in lower and middle slopes.

(6) No fellings of trees shall be allowed and if at all, any felling is to be done, it shall be done by "Selection

System" harvesting only the minimum possible.

Undertaking or river valley projects in various parts of the country does one of the major componentns of management of catchment areas.

(2) Management of forests for grazing:- The role of livestock in country's economy is a prominent one. India is predominantly an agricultural country. The use or utility of animals, as the ploughing companion, as the source of manure (cattle dung), as the source of additional economy (milching animals, sheeps and goats rearing for meat), as transporting animals to the rural mass is unquestionable. Apart from the agriculturists, the leather industry,dairy farms, etc., mostly depending upon livestock population. Any way the people who are living within the forests and in the neighbourhood of forests only use the forest as pasture grounds for their cattle. So it has become the bounden duty the Government to provide adequate facilities of pasture and fodder. There is no question of saying 'no' to grazing and only regulations and restrictions on grazing and fodder collections can be made by the Forest Department.

In olden days, forestry was considered to be the hand-maid of agriculture providing primarily all the needs of agriculture. The Britisher's 1894 Forest Policy of India classified the forests under 4 groups viz.,

(1) Forests-the preservation of which essential on climatic or physical grounds.

(2) Forests which afford or supply of valuable timber for commercial purposes.

(3) Minor Forests and

(4) Pasture lands

and laid down rules that Minor forests and pasture and grazing lands <u>must</u> be managed <u>mainly</u> in the <u>interests</u> of the population of the tract.

Dr. J.A.Voelcker who submitted a report to British Government in 1893 gave a clue to the Indian Forest Officers for winning the people's affection as follows:-

> " No action would, I am sure, do more to render the department popular and its work one of wide-spreading benefit, could it be instructed to carry out such objects as the provision, for agricultural community primarily, of facilities for obtaining what they require, viz., small timber, wood for implements, fire-wood, leaves, grass or where possible grazing".

But that was when the population was comparatively much less and their demands were limited. Much water has flown since the last decades after this report. The demands of the man-kind from forests have increased manifold and varied. Even then, the legitimate claim for grazing and fodder have to be met with by the Forest Department. Due to the multiple use of forestry, a compromise has to be struck and instead of unfettered grazing and pasture, regulated and restricted grazing has to be brought in. The following five cardinal principles

on grazing laid down by 1952 Forest Policy makers will clearly reveal the object of management of forests for grazing:-

(1) Continuous grazing on the same areas by large herds is destructive of the better strains of grasses and leads to a deterioration of the grass complex. Wherever it is permitted and is in great demand efforts should be made to introduce rotational grazing, the benefits of which should be explained and demonstrated to the villagers.

(2) Cheap forest grazing has a demoralising effect and leads to the vicious spiral of reckless increase in the number of a cattle inadequate forest grazing, reduced quality of the herds and further increase in the numbers to effect the fall in quality. Free and indiscriminate forest graz ing is, therefore, a serious disservice to cattle breeding. The notion that a farmer's wealth must be reckoned in terms of the number of cattle he owns, regardless of quality, is one of the causes of India's uneconomic cattle wealth and must be combated.

(3) Grazing should not be looked upon primarily as a source of revenue. But the simple and obvious way of regulating and controlling grazing as also improving the quality both of grazing and cattle themselves, is to istitute a reasonable fee for the privilege of grazing.

(4) Grazing must not be allowed in regeneration areas and young plantations during which such periods as the seedlings require for establishment; otherwise they stand in danger of badly browsed or trampled upon.

(5) Grazing incidence should be kept at a minimum in Protection Forests.

From the above we can deduce the objects of management of forests for grazing and they are as follows:-

(a) Grazing must be allowed but with regulations.

(b) Instead of continuous grazing by large herds, intermittent grazing with less number of cattle by means of rotational grazing shall be employed.

(c) People shall be persuaded to improve the quality of livestock instead of persisting with inferior and uneconomic low breed livestock.

(d) Pasture lands shall be improved with good quality of grasses and fodder stock.

(e) Separate paddocks shall be created to practise rotational grazing.

(f) In case of Protection Forests, grazing incidence must be kept to the minimum possible.

(g) Seasonal ban or periodic ban of graz-ing in young plantations and regeneration areas shall be practiced.

(h) To minimise grazing incidence, levying of nominal grazing fees, free cutting of grass and fodder, stall feeding by silage making use of accessory feed such as oil cakes, cotton seeds, etc., must be encouraged.

(i) Browsing animals shall never be allowed inside the forests.

For still detailed study on graz-ing management, Chapter V of Lecture Notes on " General Forest Protection" by the author may be gone through.

(3) Wildlife Management:- Flora and Fauna completes the Forest Eco-system. They are inter-dependent and inter-related. If any one is meddled with and affected, the other is also affected like Siamese twins! There are numerous examples to prove this relationship. Forests are the home of wildlife. Apart from the various benefits offered by wildlife to man-kind, they have the birth right to live in this planet equally as man. The ever-greediness of man coupled with armed arrogance, many forms of wildlife were driven to extinction and near extinction. Luckily the prudent people thought of protecting the wildlife from further disaster and started vigorous campaign for the preservation of wildlife. Thanks to their effort, now number of wild life sanctuaries, water-fowl refuges, national parks, etc. have sprung up warranting special kind of management. In India, 95% of the forests are under the control of Government and so these wild life areas situated in the forests have to be managed by Forest Department only. In the ordinary Forest management, the economic benefits are primarily considered whereas in wildlife management, environmental and nature conservation is the primary object. " Revenue" or money return comes last. But most of the areas declared for wildlife management unfortunately contain economic crops which have to be harvested making the management very complex and difficult. In such cases, we have to strike a compromise thereby minimum loss for both sides.

Wildlife management is based on following factors:-

(1) Habitat conservation and improvement.

(2) Study of wildlife population and their requirements.

(3) Keeping up or bringing to normal the wildlife population.

(4) Economic harvest of wildlife to keep the population in control and also satisfying the legitimate wants of man-kind.

(5) Facilities for research and scientific study on wildlife.

(6) Facilities for the enjoyment of people by visiting the wildlife and wilderness areas.

With these objects in mind, the wildlife areas can be divided into three main zones, viz.,

(1) Core Zone or Wilderness Zone:- There shall not be any kind of interference by man and the wildlife is allowed complete freedom to live and roam about in peace. Human interference will be limited only to the complete protection of the area from fire, intrusion of greedy men, grazing by domestic cattle, etc.

(2) Buffer Zone:- This is the intermediate zone which acts as a barrier to Core zone against fire, catastrophies and human intrusion. If the concerned areas contain valuable economical species, selective harvest can be made (as a compromise) but without affacting the overall composition of floral cover.

(3) Visitor's Zone:- This is the outermost area either surrounding the wildlife area or at the entrance of that area. Here only the quarters for the working personnel, rest houses, picnic sheds, youth hostels, etc. for the benefit of visitors are located.

Since the Wildlife management is a separate subject by itself, details can be studied in depth under the subject " Wildlife and its Management".

(4) Recreational uses of Forestry:- Regarding this aspect, western countries are much developed and well organised. For example in U.S.A., large areas of wooded country, owned by both private and Government are managed mainly for the recreational purposes. There are two major groupings of such areas as follows:-

(1) Intensively used occupancy areas:- Comprising of a) forest camp sites, b) Picnic and roadside areas c) Group or organisation camps d) Resort and Scenic areas e) Summer home areas f) Winter sport areas g) all other special use recreational areas, and

(2) Extensive Recreational Areas:- Consisting of a) Areas dedicated primarily to recreational and other non-commodity uses, b) areas on which recreational uses co-exist with other land uses, and c) areas excluded from recreational use.

But in a country like India, with second largest population in the world, having lowest per capita income, recreational use of forestry is in its infancy. Moreover, the percentage of forests is only around 20% and in which wildlife areas and natural scenic areas, fit for recreation constitute only as negligent 2%. Now only Governments in Central and States are taking steps to increase the number of places of tourist importance and provide adequate facilities for access, stay and enjoyment. At present, the tourism in India is mainly banking upon foreign tourists. For both foreign and inland tourists, only the wildlife areas are at present act as recreational areas also apart from some hill resorts such as Darjeeling, Simla, Mussoorie, Nainital, Ooty, Kodaikanal, Courtallam, Yercaud, Mahabaleshwar, Mt. Abu, Manali, etc.

So, there is little to study about the recreational forestry management as far as India is concerned at present.

The Working Plan which is written for each forest division deals with all kinds of management required within the division.

APPENDIX - I

SOME ECONOMIC TERMS EXPLAINED

1. INTERNAL RATE OF RETURN (I.R.R.):-

The term " Final yield " used in forest economic is equivalent to the term " Internal Rate of return " (I.R.R.) used in general economics. The another name given to this concept is " The marginal efficiency of Capital". The I.R.R. is that Rate of Interest which if applied to expenditures incurred at different times gives a compounded sum equal to revenues compounded at the same time."

E.g.:- A project costing Rs.1000/- in the first year to instal and yielding Rs.1,210/- two years later has an " Interest Rate of 10%" i.e. if Rs.1,000/- is the capital (Expenditure) with 10% interest, at the end of 2 years, the outstanding comes to Rs.1,210/-.

i.e. $(1000 \times \frac{110}{100})$ in 1st year = 1,100/-

the same will be in 2 years = $1100 \times \frac{110}{100}$ = 1,210/-

If the revenue at the end of 2nd year is Rs.1,210/-, the outstanding and the revenue become equal when the same interest rate is discounted on both expenditure and revenue. Therefore, I.R.R. can, in other words, be defined as " the rate of discount which makes PNW (Present Net Worth) of the investment exactly equal to zero.

I.R.R. is considered necessary for proper estimation of forest project when borrowing is contemplated at a particular rate of interest.

I.R.R. can also be defined as " the average rate earned on all costs made prior to the harvest",

2. PRESENT NET WORTH(PNW):- This term is equivalent to the term " NET DISCOUNTED REVENUE" (NDR) and in Forestry, the term " Soil Expectation Value" which is the translated German term of " BODENERWARTUNGSWERT" used by SChlich. It is explained that the returns achieved at different future dates are made commensurable by assigning to them equivalent present values. This idea was used by Faustmann in his formula, vide " Forest percent" in Chapter VI.

3. COST-BENEFIT:- In investment apprisal, the critical assessment of costs and benefits is quite essential.

Cost and prices are normally refer the " Va lues " in exchange, Costs refer to the " Value of resources" used up and prices to the Values of Goods and services produced. From the purchaser's point of view, cost is a charge incurred by purchaser equivalent to a price or revenue received by seller.

Costs are of different kinds as follows:-

OPPORTUNITY COST:- This is defined as being equal to the net benefit which would have resulted if this next best alternative had been undertaken.

This concept of opportunity cost is useful in various ways. For example, on a given unit of area (Ha) the NDR or PNW from Teak equals to Rs.500/- and from Rubber equals to Rs.300/-, then the opportunity cost of Rubber growing is Rs.500/- and since the difference is Rs.200/- this may be accounted for the psychological value to the owner of the land to go for Rubber growing instead of Teak.

Fixed and Variable Costs:- Fixed cost is the capital cost. Variable cost is the additional cost for maintenance of the capital.

In case of Forestry, Fixed cost is the capital investment value and variable costs may include wages payable to the labourers, maintenance cost, etc. Variable costs do not usually rise uniformly with increasing output.

AVERAGE AND MARGINAL COSTS:- Average and Marginal Costs are obtained from the fixed and variable costs in relation to "OUTPUTS". An example is given below in a tabular form.

AVERAGE TOTAL COST AND MARGINAL COST

Output units	Fixed cost	Variable cost	Total Cost	Average Cost	Marginal cost
1	10	2	12	12.0	2
2	10	5	15	7.5	3
3	10	9	19	6.3	4
4	10	14	24	6.0	5
5	10	20	30	6.0	6
6	10	28	38	6.3	8

Benefit:- Benefits are of two kinds, namely, Tangible and Intangible benefits. We now consider only Tangible benefits. Under this category there are two types as follows:-

(a) Those which are marketed, and
(b) Those which are either marketable but are not marketed or not marketable.

The former is considered in Forest economics. Marketed benefits in forestry relates to wood and wood products. So, the price of wood and wood products shall be determined. Again, for this determination, the demand and supply of the wood and wood products, the current price, future yield, felling intensity (Regulation of Yield), price variation, etc., have to be analysed.

Cost and Benefit Analysis:- As Johnston, D.R. put it, " The forests are valued for their goods and services". The goods from forests are major and minor forest produces.

When a project is contemplated, the costs and benefits are analysed to see whether the net benefits rise up to give the required return or investment. So, the main function of Cost-benefit analysis is to apprise the economic effects of a given project. It measures these effects in "Money" terms. Cost and benefit analysis is applied for both marketable and unmarketable goods. The aim of this analysis is

to correct for any distortions prevailing in the market. It also tries to assess unmarketable benefits such as environmental effects. In India, Cost-benefit analysis is used in the context of planned development and its use is limited to the analyses of nuclear power research, family planning programme, road transport undertakings, irrigation projects, industrial enterprises and few other activities; but yet to be applied in forestry activities, the great handicap being utter lack of proper datas which are the basic for such analysis.

DISCOUNTING:- This concept is also one of economics. This, in fact, the reverse of Compounding. In case of compounding, the investment on the capital, the maintenance cost, etc. are compounded with the particular rate of interest for particular period to arrive at the profit to be estimated or to be obtained through a project. But by means of discounting with the particular rate of interest for particular period, we can arrive at the investment which was put at the beginning of the project, or that matter the Present Net Worth (PNW) can also be arrived at.

APPENDIX - II

Synopsis of Guest lectures delivered by Shri R.L.Choudhary, Regional Manager, Forest Development Corporation of Maharashtra, Ltd., Nagpur, to the probationer Asst. Conservators of Forests of the State Forest Service College and trainees of the Southern Forest Rangers College, Coimbatore, on 18-10-1983 and 19-10-1983 at Coimbatore.

Shri R.L.Choudhry,I.F.S.

" Application of Economic Analysis to Forest Harvesting Decisions".

Forest harvesting is one of the most critical decisions which a Forest Manager is called upon to make in the management of Forest properties in his charge. In arriving at such a decision, a variety of factors like biological nature of the resource, economic forces operating in the society and considerations of ecological security, etc. have to be taken into account. So far, the Forest Managers were giving undue weightage to the biological considerations and silvicultural requirements of the crop in fixing rotation period. In case of unique forests resources like preservation plots, biosphere reserves, etc. these considerations alone may be appropriate. But when one considers large extent of renewable forest resources which are to be managed for satisfying the needs of a diverse segment of population, biological or physical considerations alone for rotation fixation are not an adequate guide. In an era of growing scarcities of almost every inputs (e.g. land and capital) going into forestry systems and the outputs (e.g. timber, firewood, poles, fodder, bamboos, etc.) emerging therefrom, allocative efficiency of resources tied down to forestry assumes great importance. This calls for some straight answer to questions like - Is the forestry production technology, management level and product-wise appropriate to meet the growing needs of the society and at minimum of cost? The answer to such question can be furnished only after assessment of the alternatives available to a Forest Manager to meet his objectives and evaluation of the associated costs with each of these alternatives.

Unfortunately, for the lack of time such important questions of forest management like " what quantity of (forest) product leads to maximum net revenue, how much of each necessary input should be used, the relative amount of different productive factors, the proportionate amount of several timber and non-timber products produced", etc. cannot be dealt with in these lectures. The references attached to this synopsis may be seen for likely answer to these questions. Our concern in these lectures is with the " time " aspect of timber production decisions. Forest growing stock is a forest capital and the question of how much capital should be invested for how long a time is important for timber production economics. The task is to assess how time affects factors like interest rates, growth rates, revenues, costs, etc. is one of fundamental importance in rotation determination. To illustrate the effects of these factors, data of Pine plantations in Chile (reproduced from the book Forest Resources Economics by G.R.Gregory - Page 275 is taken).

Table 1 - Calculation of present net worth, soil expectation, internal rate of Return, and Forest Rent
(Interest Rate at 6 per cent, price at 4 per cubic foot, annual cost of $2.00)*

Year	Yield	Total revenue	Marginal revenue	Total costs	Marginal cost	Net revenue	Forest rent	Se value	Present net worth	Internal rate of return
5	270	10.80	10.80	53.80	4.93	-43.00	-6.24	-127.14	-32.13	..
6	597	23.88	13.07	59.03	5.22	-35.15	-3.35	- 83.99	-24.78	..
7	946	37.84	13.96	64.57	5.54	-26.73	-1.16	- 53.08	-17.77	..
8	1,320	52.80	14.96	70.44	5.87	-17.64	0.59	- 29.71	-11.07	1.3
9	1,721	68.84	16.04	76.67	6.22	- 7.83	2.09	- 11.36	- 4.63	4.3
10	2,150	86.00	17.15	83.27	6.59	2.72	3.39	3.44	1.52	6.3
11	2,608	104.32	18.32	90.26	6.99	14.05	4.57	15.64	7.40	7.5
12	3,096	123.84	19.52	97.68	7.41	26.15	5.05	25.84	12.99	8.4
13	3,616	144.64	20.79	105.54	7.86	39.09	6.66	34.50	18.32	9.0
14	4,171	166.83	22.19	113.87	8.33	52.96	7.63	42.00	23.42	9.5
15	4,766	190.64	23.80	122.70	8.83	67.93	8.57	48.64	28.54	9.7
16	5,403	216.12	25.48	132.07	9.36	84.04	9.50	54.56	33.08	9.9
17	6,078	243.11	26.99	141.99	9.92	101.12	10.41	59.73	37.55	9.9
18	6,763	270.52	27.39	152.51	10.51	118.00	11.25	63.63	41.34	9.9
19	7,440	297.60	27.08	163.06	11.15	133.93	11.97	66.12	44.26	9.9
20	8,095	323.80	26.20	175.48	11.91	148.31	12.59	67.19	46.24	9.9
21	8,712	348.48	24.67	188.01	12.52	160.46	13.07	66.87	47.20	9.7
22	9,295	371.80	23.32	201.29	13.28	170.50	13.44	65.49	47.31	9.5
23	9,845	393.80	22.00	215.36	14.07	178.43	13.73	63.27	46.71	9.2
24	10,363	414.52	20.71	230.28	14.92	184.23	13.93	60.42	45.50	9.0
25	10,850	434.00	19.47	246.10	15.81	187.89	14.07	57.07	43.77	8.8
26	11,310	452.40	18.40	262.87	16.76	189.52	14.16	53.39	41.66	8.5
27	11,745	469.80	17.40	280.64	17.77	189.15	14.21	49.48	39.22	8.3
28	12,156	486.23	16.43	299.48	18.83	186.75	14.22	45.42	36.53	8.1
29	12,545	501.80	15.56	319.44	19.96	182.36	14.20	41.27	33.65	7.9

* Basic yield data adopted from that of Lota, Chile; Planting cost assumed at $28 per acre, and a single weeding made at end of first year with cost of $4 per acre.

From this data the net revenue from plantations is maximised at the age of 26. Should we adopt this as rotation age for plantation? Before one answer this question, let us review briefly the four approaches which maximise respectively. Present net worth, Soil Expectation value, Internal rate of return and forest rent. The calculation steps are briefly given below:

PRESENT NET WORTH (PNW):

This is an expression of net revenues from plantations discounted to a common time point for ensuring of costs and revenues from plantation comparability which occur at different periods of time.

$$PNW = \frac{\sum_{t=0}^{r} Rt\,(1+i)^{r-t} - \sum_{t=0}^{r} C_t(1+i)^{r-t}}{(1+i)^r}$$

Where R_t is a revenue received at time t, Ct is a cost incurred at time t, r is the rotation age, and i is the interest rate, with the present being defined as t = 0.

From the data, the PNW is maximised ($ 147.31) under a 26-year rotation - an in-put of 22 years.

SOIL EXPECTATION VALUE (Se)

The term has been coined by Martin Faustmann - A German Forester and denotes the cash amount one may be willing to pay for bare land given the pattern of costs, revenues that one can expect from the plantations raised on these lands. While the present Net worth gives the discounted net revenue for one rotation only the Se value gives the discounted net revenue from infinite rotations, i.e. it is assumed that the land in question will always be under the plantation of the chosen species and for all time to come. These value is calculated as below:

$$Se = \frac{\sum_{t=0}^{r} R_t(1+i)^{r-t} - \sum_{t=0}^{r} C_t(1+i)^{r-t}}{(1+i)^{r-1}}$$

Where the symbols have usual meaning as given in PNW formula.

The Se value is maximised ($67.19) with a time in-put of 20 years.

It is pertinent to note here that if maximum Se value ($67.19) is taken as a land cost and included in C_t in PNW calculations, the time in-put i.e. rotation calculated from PNW or Se approach will be one and the same.

INTERNAL RATE OF RETURN (IRR):

This is the "average rate earned on all costs made prior to the timber harvest ". A simple formula for these calculations is as below:

$$\sum_{t=0}^{r} C_t(1+i)^{r-t} = \sum_{t=0}^{r} R_t\,(1+i)^{r-t}$$

In this equation both I and r are unknown. Therefore, tables which give the value of $(1+i)^n$ are to be used and the rate at which

the two sides balance has to be found by trial and error method.

IRR is maximised with an investment period of 16 years (9.9%)

When the funds for forestry investments are borrowed from banks, this indicator is useful to assess returns from investments vis-a-vis cost on account of borrowals.

FOREST RENT:

This is the average annual net revenue when net revenue is defined as Gross revenue less total cash cost except interest charges. The assumption here is that there is no cost on capital invested in the forests, but this assumption is no more valid a forestry uses scarce in-puts like land capital, skills, etc. and each of these have definite cost to the society. Hence, this approach is ignored for rotation determination.

FACTORS AFFECTING INVESTMENT (ROTATION) DECISIONS:

1) Impact of Growth factors: If a genetically superior strain of a particular species is introduced, the cost remaining the same PNW will be maximised at longer rotation.

2) Effect of Changing product prices:

This would have similar effect of lengthening the rotation as the total costs are not affected but the total revenue undergoes substantial changes.

3) Changing site quality:

Better the growth condition better the revenues and if costs are assumed to be the and the same for each of the site quality, rotations on better site quality areas would be longer as compared to inferior sites.

4) Effect of thinnings: Periodic thinnings permit better growth and consequently increased revenues. If the revenues obtained in these thinnings is more than the costs on these operations, the sum and total of these operations will result in lengthening of investment period.

5) Changing Interest rates: High interest rates favour adoption of shorter investment period and vice-versa.

6) IMPOSITION OF TAXES: Imposition of taxes on produce will reduce the total revenues and consequently shorter the rotation period.

Although above are the general observations about the impact of various factors on rotation, in each case the effect of these factors on costs and revenues have to be calculated before arriving at the final answer.

From this data the net revenue from plantations is maximised at the age of 26. Should we adopt this as rotation age for plantation? Before one answer this question, let us review briefly the four approaches which maximise respectively. Present net worth, Soil Expectation value, Internal rate of return and forest rent. The calculation steps are briefly given below:

PRESENT NET WORTH (PNW):

This is an expression of net revenues from plantations discounted to a common time point for ensuring of costs and revenues from plantation comparability which occur at different periods of time.

$$PNW = \frac{\sum_{t=0}^{r} Rt\,(1+i)^{r-t} - \sum_{t=0}^{r} C_t(1+i)^{r-t}}{(1+i)^r}$$

Where R_t is a revenue received at time t, Ct is a cost incurred at time t, r is the rotation age, and i is the interest rate, with the present being defined as t = 0.

From the data, the PNW is maximised ($ 147.31) under a 26-year rotation - an in-put of 22 years.

SOIL EXPECTATION VALUE (Se)

The term has been coined by Martin Faustmann - A German Forester and denotes the cash amount one may be willing to pay for bare land given the pattern of costs, revenues that one can expect from the plantations raised on these lands. While the present Net worth gives the discounted net revenue for one rotation only the Se value gives the discounted net revenue from infinite rotations, i.e. it is assumed that the land in question will always be under the plantation of the chosen species and for all time to come. These value is calculated as below:

$$Se = \frac{\sum_{t=0}^{r} R_t(1+i)^{r-t} - \sum_{t=0}^{r} C_t(1+i)^{r-t}}{(1+i)^{r-1}}$$

Where the symbols have usual meaning as given in PNW formula.

The Se value is maximised ($67.19) with a time in-put of 20 years.

It is pertinent to note here that if maximum Se value ($67.19) is taken as a land cost and included in C_t in PNW calculations, the time in-put i.e. rotation calculated from PNW or Se approach will be one and the same.

INTERNAL RATE OF RETURN (IRR):

This is the "average rate earned on all costs made prior to the timber harvest ". A simple formula for these calculations is as below:

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In this equation both I and r are unknown. Therefore, tables which give the value of $(1+i)^n$ are to be used and the rate at which

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APPENDIX - III

MODEL QUESTION PAPERS

FOREST MANAGEMENT

Final Examination of 1980-82 batch - 29-12-81

Time: 3 hours Max. marks: 150

1. Answer only six (6) questions, in all.
2. Question No.8. is compulsory.

I. What do you understand by the term " Normal Forest"? Mention various kinds of abnormalities met with giving reasons for same briefly.

II. Classify the silvicultural systems commonly practised in Indian Forests, mentioning briefly the factors, that influence the choice of the silvicultural system.

III. Why is a Working Plan essential for scientific management of forests? Describe briefly the different stages in the preparation of a Working Plan.

IV. How is yield regulated by volume based on the growing stock? What are its advantages and disadvantages? Explain very briefly any method of yield regulation studied on tour.

V. Explain briefly giving reasons, the silvicultural system adopted in working the following forests:

a) Poor quality dry mixed deciduous forests in M.P.
b) Bamboo forests in Andhra Pradesh
c) Mysore hybrid Eucalyptus plantations in Tamilnadu.
d) Sal forests in South Raipur Division.

VI. Differentiate between following, explaining each term's meaning:-

(a) Stock map and Treatment map.
(b) Current and Mean Annual Increment.
(c) Seedling felling and Secondary felling.

VII. Write brief notes on any four of the following:-

(a) Local Volume Tables
(b) Floating Periodic block
(c) Control journal
(d) Money yield tables
(e) Increment percent.

VIII. What is " Multiple use Forestry?" Explain the importance of same in the context of dwindling and degrading forest resources in our country.

1981-83 Batch - Mid-term Examination

Time: 3 hours | Max. marks:100

Note:- All questions carry equal marks.
Answer any five questions.

I. Define " Principle of Sustained Yield" and discuss the merits and demerits of the principle.

II. What is meant by rotation? What are the different kinds of rotation? Describe briefly the basic factors considered in fixing rotation.

III. (a) Indicate the purpose of increment percent.
(b) Find out the increment percent of the crop, given the following data by using Pressler's formulae:-
Volume of a crop of 40 years : 200 cubic metre.
Volume of the crop at 50 yrs.: 300 cubic metre.
A thinning at 45th year yielded 20 Cubic metre.

IV. Define and explain " Normal Forests" and also of the different kinds of abnormalities.

OR

Define CAI & MAI and bring out the mathematical relationship between the two and its importance in Forest Management.

V. Write short notes on any Five of the following:-
1. Working plan
2. Principle of progressive yield
3. Conversion
4. Effect of thinning on volume increment.
5. Flury's Constant
6. Money Yield Tables
7. Periodic Block.

VI. Describe the distribution of age classes or age gradations in any two of the following:-
1. Felling Series in clearfelling system.
2. Felling Series in regular Shelterwood System
3. Felling Series in irregular Forests
4. Felling Series in Coppice with standards.

OR

(a) Explain with diagram the relationship between Increment and Growing Stock.

(b) Find out the Summer, Spring and Autumn Growing Stock with following data:-
Rotation : 100 years; Increment - 5000 Cub. metre.

VIII. By using mid-season formulae (Calculation of growing stock from yield table), find out the growing stock in a normal Teak forest of I quality given the following data:-

Area : 50 ha.; Rotation : 30 yrs.; Yield Table figures for 30 Ha.

Age	Volume of Stem timber
5	0
10	340
15	710

20	1160
25	1650
30	2180

OR

(a) Explain the importance of "reducing factor" with reference to the principle of sustained yield.

(b) Find out the reduced area for 10 ha. of real area from the following data:-

Quality Class	Yield per ha. in Cu. metre.
I	3600
II	2700
III	1800
IV	900

Final Examination of 1981-83 batch

Time: 3 hrs. 27-12-1982 Max. marks: 150

Note:- 1. Answer any six questions in all.
2. Question I is compulsory.

I. A 1000 ha. forest block containing recently degraded dry deciduous forest and surrounded by densely populated villages, is to be managed to meet the local requirements for all kinds of forest produce. Afforestation in small plots with suitable species and enrichment planting can be resorted to if necessary. Please draw up a comprehensive management plan for the forest block to meet the stated objective.

II. What do you understand by the word " Three dimensional Forestry"? Explain how in a rural setting the forests should be managed to achieve multiple use objectives.

III. A normal forest is only a theoretical concept rarely achieved in practice. Do you agree? If so mention reasons, giving causes for various kinds of abnormalities noticed.

IV. Define " Principle of sustained yield" and discuss the merits and demerits of the principle.

V. What are the various kinds of rotations commonly adopted in Indian forestry today. Explain briefly the various considerations that govern the choice of each of those rotations. What do you consider the proper type of rotation for managing Teak plantations raised in a semi-moist-region.

VI. Explain briefly the "Brandis" method of yield regulation in forests, mentioning its advantages and disadvantages.

VII. What is the difference between a Working Plan and Working Scheme? Explain briefly the field work to be undertaken for preparation of a Working Plan for an extensive forest located in hilly terrain and to be brought under systematic

management for the first time.

VIII. Write brief notes on any four of the following:-

a) Reduced area
b) Conversion period
c) Increment percent
d) Yield table
c) Smythie's Safeguarding formulae

PERIODICAL EXAMINATION OF 1982-84 BATCH

Time: 3 hrs. 5-10-83 Max. marks: 50

Note:- 1. Answer all questions.
2. All questions carry equal marks.

I. Discuss what are the objects of Forest Management.

II. Discuss what you understand by the concept " Sustained Yield " together with its merits and demerits.

III. Define Rotation. What are the various types of rotation? Describe how rotation of maximum volume production is determined.

IV. What do you understand by Normal Growing Stock? What are the various kinds of abnormalities noticed in a growing stock. What are the causes of these abnormalities and what management techniques do you propose to bring the various types of abnormal forests to near normality?

V. Write short notes on the following:-

a) Working Plan
b) Reducing Factor
c) Pressler's formula
d) Equal area and equiproductive area.

FINAL EXAMINATION OF 1982-84 BATCH

Time: 3 hrs. Max. marks: 150

Note:- 1. Answer any six questions in all.
2. Question I is compulsory.

I. Is there any incompatibility between the concepts of "Sustained yield" and present management practices on one hand and the role of forests in maintaining ecological balance and environmental stability? Discuss.

II. Write short notes on any five of the following:-

1) Reduced area
2) Increment percent
3) B/C analysis
4) Money yield tables
5) Smythie's safeguarding formula
6) Rotation and felling cycle
7) IRR
8) Normal Forest.

III. Describe Brandis and Smythie's formulae and discuss their merits and demerits.

IV. What is periodic method of yield regulation? Briefly describe the method as under application in any forest you may have seen during tours.

V. Define and enumerate different types of rotations. Comment on what considerations should weigh in determining the "rotation" of a commercial plantation project (i.e. raised by borrowing interest-bearing loans) proposed to be taken up by a community to meet its fuelwood needs.

VI. Explain the terms " Working Circle ", " Felling Series", and "Coupe". Is a "Felling Series" concept essential in captive plantation projects undertaken by wood based industries? Discuss.

VII. Explain briefly the principles involved in the preparation of a Working Plan. What are the major drawbacks in the implementation of a Working Plan as you may have understood during your tours?

VIII. A farmer wishes to consider the relative financial advantages/disadvantages of raising a tree crop as against annual agricultural crop. How would you proceed to work out the options?

REFERENCE

1.	Bala Kathiresan, S.	-	Lecture Notes on Forest Policy
2.	-do-	-	Lecture Notes on Forest Protection
3.	Brasnett, N.V.	-	Planned Management of Forests
4.	Charles, H. Stoddard	-	Essentials of Forest Practice
5.	Chaturvedi, A.S. & Khanna L.S.	-	Forest Mensuration
6.	F.R.I., Dehra Dun	-	Glossary of Technical Terms
7.	-do-	-	India - Forests, 1980
8.	Jerram, M.R.K.	-	Forest Management
9.	Johnston, D.R. et al	-	Forest Planning
10.	Mathur, V.P.	-	Forest Management
11.	National Commission on Agriculture.	-	Part IX of NCA Report.
12.	Osmaston, F.J.	-	The Management of Forests
13.	Sharma, L.C.	-	Forest Economics, Planning and Management.
14.	Tamilnadu Government Publication	-	Task Force Report on Forestry - 1972-84
15.	Tamilnadu Government Publication	-	Working Plan for Madurai North Dn. 1958-68
16.	U.P. Government	-	Working Plan for Haldwani 1975-85